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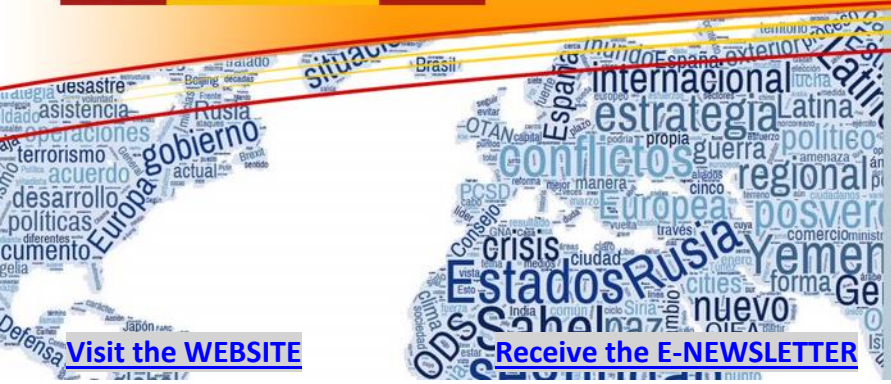
Microelectronics growing up in the global geostrategic context



Microelectronics growing up in the global geostrategic context

Abstract:

Microelectronics continues to be one of the main fields where international stress manifests. The scenario resulting from globalization, where very few actors hedged a big part of the relevance of the sector, has combined with the shift in the geopolitical context, what has pointed out the problems for the States posed by the lack of strategic sovereignty and the growing dependence in questions that, given the current trends, will gain more and more relevance.

The nature of the problems has overgrown pure technological questions, like access to technology, its fabrication and the raw materials required for it. They are reaching political and geostrategic dimensions whose consequences start to be measurable in industrial and economic terms. The effects and limitations of the applied measures are blossoming with declarations and sector data that are waking up the alarms.

Keywords:

Microelectronics, sanctions, geostrategy, geopolitics, industrial policy

La microelectrónica crece en el contexto geoestratégico global

Resumen:

La microelectrónica continúa siendo uno de los principales campos en los que la tensión internacional se pone de manifiesto. El escenario resultante de la globalización, en el que muy pocos actores ostentaban una gran parte de la relevancia del sector, se ha combinado con el cambio de la coyuntura geopolítica, lo que ha acentuado los problemas que suponen para los estados la falta de soberanía estratégica y la creciente dependencia en cuestiones que, dadas las tendencias actuales, cada vez van a adquirir una mayor relevancia.

La naturaleza de los problemas ha trascendiendo las cuestiones puramente tecnológicas, como el acceso a la tecnología, a su fabricación y a los materiales necesarios para llevarla a cabo. Están alcanzando dimensiones políticas y geoestratégicas cuyas consecuencias empiezan a ser medibles en términos industriales y económicos. Los efectos y limitaciones de las medidas adoptadas se están haciendo evidentes con declaraciones y datos del sector que generan cierta alarma.

Palabras clave:

Microelectrónica, sanciones, geoestrategia, geopolítica, política industrial.

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The supply chain in the microelectronics sector includes a diverse range of companies whose geographic distribution is directly related to the type of supply chain operation the company is engaged in. The more design-related jobs, with highly skilled labour profiles, are concentrated in western countries, while the lower value-added functions in the chain, such as manufacturing, materials, packaging, testing and distribution, tend to move further east on the world map, as it is commonly depicted.

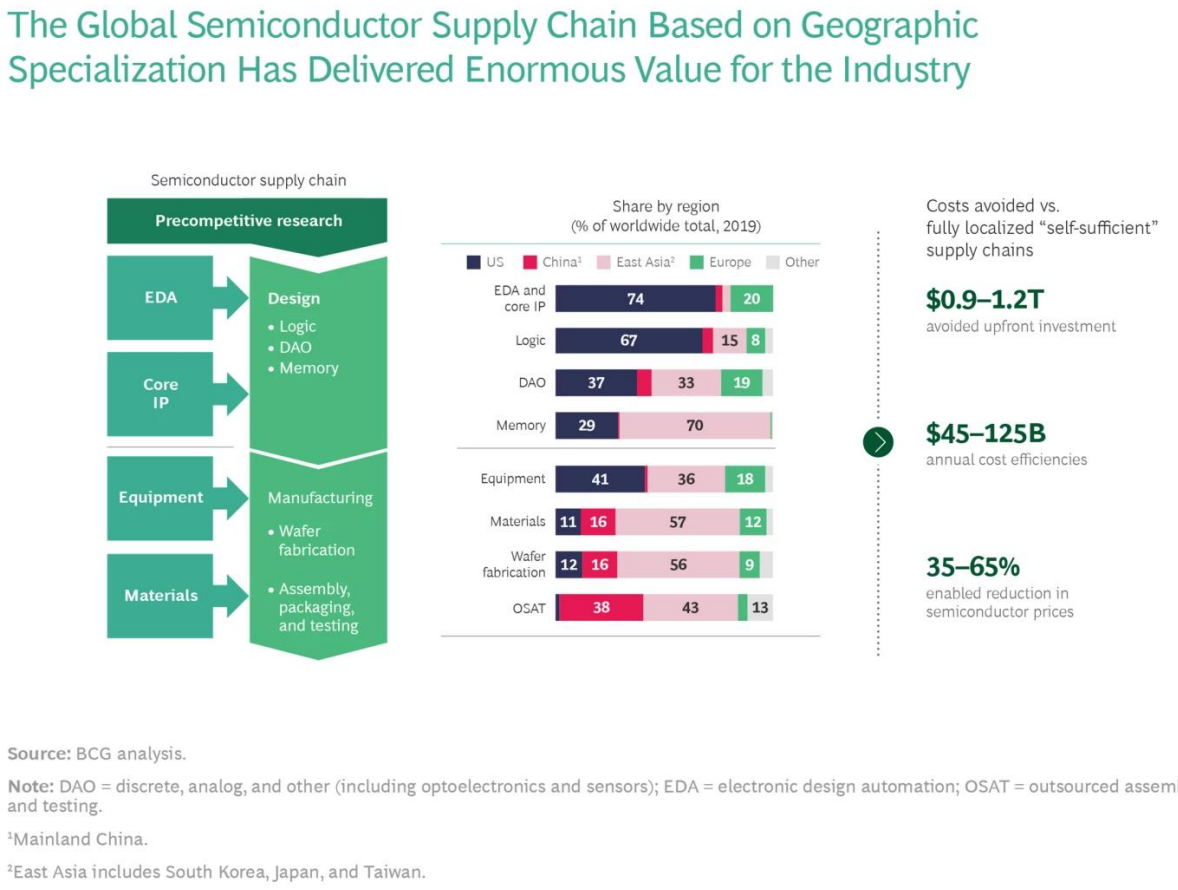


Figure 1 Semiconductor supply chain (Source: BCG[1])

The compatibility of this distribution of the different links in the supply chain relies on globalisation and the openness of markets, which allow for the intermediate products produced by some actors to constitute the necessary inputs for others to carry out their work. This not only involves tangible products such as refined materials, equipment and components of more complex products, but also of particular relevance is the transfer of intellectual property allowing and enabling the use of these intermediate products. The

[1] VARAS, Antonio et al. *Strengthening the Global Semiconductor Supply Chain in an Uncertain Era*. https://www.bcg.com/publications/2021/strengthening-the-global-semiconductor-supply-chain

imposition of barriers to this traffic acts as a brake on production chains and requires a redesign in order for the various separate spaces to incorporate the functions which, because of limitations, blockages and sanctions, have ceased to be accessible. In this scenario, the West would be required to strengthen manufacturing and electronic packaging type work, while the East would have to work on the development of designs, technologies and manufacturing equipment, which it traditionally procured from the West.

Blockades also apply to finished products, with export bans on certain products to specific countries as well as limitations on the use of certain technologies from specific suppliers. In both cases, companies' markets are directly affected, leading to inefficiencies that had seemingly been eliminated and to cyclical changes in companies as a consequence of reductions in turnover and cost increases.

The entire supply chain, from raw materials to the marketing of products, has therefore been affected by the current geopolitical situation, the evolution of which has accelerated in recent years and prevents forecasting over time with any meaningful level of certainty.

International relations in action

As acknowledged by experts in the microelectronics industry, the bans imposed by the US government on its industries on selling chip-making equipment to China were insufficient without their being coordinated with a block on the sale of technologies from other global manufacturers.[2]

President Biden contacted the Dutch and Japanese governments directly to make a joint ban on the sale of equipment for the manufacture of the most advanced technology nodes devices, which use the EUV, extreme ultraviolet, and DUV, deep ultraviolet, photolithographic techniques. The intention was to curb China's ability to produce products of technology nodes below 10 nm using Western technology and industrial property, appealing to national security to justify these actions.

The Netherlands responded to the negotiation with the US by extending the block on the sale of material for the manufacture of integrated circuits likewise to DUV technologies, which give access to manufacturing processes of up to 10nm. These are not the most

[2] BATEMAN, Jon. *U.S.-China Technological decoupling*. Ch. 10
https://carnegieendowment.org/2022/04/25/competing-and-leading-in-strategic-industries-pub-86926

technologically advanced nodes, although their characteristics are sufficient to incorporate the new digitisation paradigm in areas that require processing but not the highest performance. From simple automation in the Internet of Things to digital circuits embedded in vehicles and installations, there is a need for devices which, with limited power consumption, provide the necessary features to carry out simple tasks and tasks of limited complexity, such as automation, sensor management and data transmission.

US relations with Japan in the field of microelectronics have been replicated since Joe Biden took office[3]. The two most important companies involved were Nikon and Canon, both of which produce DUV manufacturing technologies. Shortly afterwards, the Japanese government raised the possibility of relaxing this blockade in view of its potential strategic consequences.[4]

The trade-offs between strategic leadership and economic interest also lead to reflections on the impact these blockages can have not only on the microelectronics sector but also outside the specific sector, on other technology sectors where these blockages can be a disproportionate brake on the unstoppable evolution of the introduction of technology into societies.[5] For certain market areas, such as users' mobile handsets, these technologies do not represent a strategic advantage because the value chain has already been optimised in a market where price competition is a must. The desirability of relaxing blockades in these areas has been raised. The Chinese Semiconductor Industry Association (CSIA) issued a statement on the blockade, denouncing precisely these issues: "CSIA opposes the act of interfering in global trade liberalisation, distorting the balance of supply and demand", claiming that the semiconductor industry thrives thanks to the global market and collaborative innovations, and that the measures imposed will cause serious damage to the Chinese industry, the global economy and the interests of consumers worldwide.[6]

[3] MARTIN, Dylan. *US to help Japan make leading-edge 2nm chips, possibly by 2025* https://www.theregister.com/2022/06/15/us_japan_chips/
[4] TAKENAKA, Kiyoshi and KELLY, Tim. *Japan may opt for milder chip-equipment curbs on China than the U.S, says lawmaker* https://www.reuters.com/technology/japan-may-opt-milder-chip-equipment-curbs-china-than-us-says-lawmaker-2023-02-08/
[5] BATEMAN, Jon. *U.S.-China Technological decoupling*. Ch. 10 https://carnegieendowment.org/2022/04/25/competing-and-leading-in-strategic-industries-pub-86926
[6] DOBBERSTEIN, Laura. *Chinese semiconductor industry: This Western chip ban alliance stinks.* https://www.theregister.com/2023/02/16/chinese_semiconductor_industry_ban/

The US government's bilateral agreement with the Dutch government regarding a company based in the Netherlands should be contrasted with the EU's Common Security and Defence Policy. If a motivation of the agreement was the preservation of national security, undoubtedly the Dutch government has full sovereignty. If, however, the agreement is underpinned by issues of international security interest, perhaps the EU should have taken action in view of the possible consequences of this decision by one Member State for the rest of the European partners. Aside from these two situations, if this issue is an economic one, it could be a violation of international trade rules and also a breach of the rules of the World Trade Organisation, WTO, as China has pointed out in their complaint[7].

Tackling blockages

Countries affected by blockades experience a supply chain problem for many of the technologies necessary for their normal functioning. Consequently, they have launched initiatives to address the problem of constraints and recover the capacities they gained through the importation of technologies.

The path of supplier diversification is the one that permits the fastest recovery of capacities. However, the microelectronics market is highly concentrated and replacing some devices or equipment with others that perform similarly is not an easy task. Not only is the purchase of final products being blocked, but previous stages of the supply chain are too, including device production tools, raw materials, technologies, etc. In fact, as mentioned above, this capacity recovery route had already been considered and international agreements were made to shut down this possibility.

That said, by tapping secondary markets, both Russia and China have continued to buy technologies to which they have blocked access.

The Wall Street Journal pointed to at least 30 research articles on the use of American semiconductors to which China should not in theory have access[8], while simultaneously reporting that 94% of exports to China of sensitive technologies were authorised by the

[7] ROBINSON, Dan. China files complaint with WTO against US chip export controls. https://www.theregister.com/2022/12/13/china_files_complaint_with_wto/
[8] MANN, Tobias. *China shops around US bans to power its nuclear weapons research program* https://www.theregister.com/2023/01/31/china_us_nuclear/

US Department of Commerce[9]. Manufacturers of certain devices are even modifying their product lines to be able to continue to market devices, including graphics cards that can be used for computationally intensive algorithms, the performance of which the manufacturers reduce to fall just within the limits imposed by the sanctions.

Russia, for its part, was also using side channels to acquire technology, although this route is in no way problem free. According to an article in the Russian business daily Kommersant, devices purchased from China, under the "friendship without limits" agreement declared between Moscow and Beijing in 2022, have a failure rate of around 40%, an increase of around 1,900% compared to the traditional failure rate of these products.[10] These figures contrast with the astonishing 209% growth in Chinese semiconductor exports to Russia.[11]

In terms of developing its own capabilities, the contrast between the state of Russian and Chinese industry, the main players affected by the technological blockades, is stark.

Nonetheless, albeit much more discreetly, Russia is also progressing in the development of Elbrus processors. In a demonstration carried out for a subsidiary of one of Russia's largest banks, Sber bank, technicians responsible for evaluating the technology reported the result of the experiment of integrating technology developed on Russian territory to perform workloads that have traditionally been carried out using Western technology. The critical judgement:

> "The Elbrus-8C server is very weak compared to Intel Xeon 'Cascade Lake'," said Anton Zhbankov, a representative for SberInfra, at the Elbrus Partner Day conference (via ServerNews.ru) earlier this month. "Insufficient memory [256MB], slow memory, few cores, low frequency. Functional requirements have not been met at all".[12]

[9] MANN, Tobias. The trade ban that wasn't: US allows 94% of restricted tech exports to China anyway https://www.theregister.com/2022/08/17/china_us_export_ban_truth/
[10] SHARWOOD, Simon. *China dumps dud chips on Russia, Moscow media moans.* https://www.theregister.com/2022/10/18/russia_china_semiconductro_failure_rates/
[11] PANDEY. Ansh. *China plotted to paralyze Russia's defence manufacturing sector by sending faulty chips* https://tfiglobalnews.com/2022/10/21/china-plotted-to-paralyze-russias-defence-manufacturing-sector-by-sending-faulty-chips/
[12] SHILOV, Anton. *Russian-Made Elbrus CPUs Fail Trials, 'A Completely Unacceptable Platform'* 3/1/2022 https://www.tomshardware.com/news/russias-biggest-bank-tests-elbrus-cpu-finds-it-unacceptable

was not a good report for the technology, although the mere fact that it had fulfilled its intended function, given that it was a prototype, was acknowledged to have far exceeded the expectations of the technicians in charge of carrying out the exercise.

The cost of blockades

The eminently private nature of the sector, with significantly sized companies, the vast majority of which are listed on stock exchanges, means that their regulatory reporting requirements reflect the impacts that blockades can have on their income statements.

Several companies, from the most important ones such as AMSL and TSMC, which are regularly in the press, to other smaller but very relevant companies in the sector, have put figures to the impact these blockades can have on their business model.

The Dutch company AMSL, which provides manufacturing equipment for the most advanced and smallest nodes, may be affected by the decision to ban equipment sales. Around 15% of its revenues came from marketing its products in China, amounting to a turnover of around €3 billion. In the case of the American company Lam Research, the loss of revenue due to the ban is estimated at €2.5 billion. In November 2022, the American company Applied Materials also announced that the ban would reduce its revenues by around 10%, to the tune of €2.5 billion.[13]

Aside from the economic impact, employment in the sector is also affected, with announcements such as the one made by LAM Research, that 1,300 people will be laid off due to the impossibility of exporting its devices to China, and that the plan is not to renew the contracts of a further 1,400 temporary workers.

While TSMC CEO C.C. Wei did not go into specifics on the impact the measures will have on the business, he did describe the effects that geopolitics is having on the context in which the company operates, referring to the *death* of globalisation, echoing company founder Morris Chang at an earlier conference[14], and the problems that vetoes and sanctions impose on the industry.[15]

[13] MANN, Tobias. *US pressures Asian allies to join crusade against Chinese chipmakers* https://www.theregister.com/2023/01/09/us_china_japan_chips
[14] TING-FANG, Cheng. *TSMC founder Morris Chang says globalization 'almost dead* https://asia.nikkei.com/Spotlight/Most-read-in-2022/TSMC-founder-Morris-Chang-says-globalization-almost-dead
[15] TING-FANG, Cheng. *Geopolitical rivalries distorting chip market: TSMC CEO.* https://asia.nikkei.com/Business/Tech/Semiconductors/Geopolitical-rivalries-distorting-chip-market-TSMC-CEO

Restructuring and subsidies

The vulnerability and dependence revealed by the COVID-19 pandemic and the changing global geopolitical situation have led to numerous semiconductor-related initiatives worldwide.

Securing the supply chain has opened the door to requesting the installation of technological capabilities in new locations, while strategic dependence is driving the creation of local capabilities that can provide the necessary products even when confronted with unexpected international events.

The importance of microprocessor technologies for the technological development of states is paramount, and is also reflected in new investment initiatives to pursue the market relevance of local companies and capabilities.

India is an example of the latter with its plans to develop local capabilities to gain a leading role in the sector. It will invest in two semiconductor factories, two display factories and 15 semiconductor packaging plants, and will support 100 domestic semiconductor design companies.[16]

In this mature market wherein dominant producers can impose conditions to bring their production capacities to locations where there is strategic interest, bids from different territories struggle in their attempt to get foreign manufacturers to locate new manufacturing plants in their territory. There are abundant examples of regions that offer tax incentives or contributions to encourage the creation of a facility in their territory.

Korea's Samsung will build a new factory in Texas in exchange for a property tax reduction of 92.5% for the first 10 years, 90% for the next 10 years and 85% for 10 more years. A total of 1,800 new jobs are envisaged, which will undoubtedly contribute to the revitalisation of the area.[17] The question is, does this investment respond to Samsung's strategic interests, to requirements for the company to manufacture in certain locations to access certain markets, or to purely economic motivation?

[16] SHARWOOD , Simon. *India makes $10B bid to grow local semiconductor industry to serve - and challenge - the world* https://www.theregister.com/2021/12/16/india_semiconductor_mission/
[17] QUACH, Katyanna. *Samsung offered tax rebates for 30 years to build $17bn chip plant in Texas* https://www.theregister.com/2021/09/07/samsung_intel_chip_fab/

TSMC will also increase its production in the US by investing €40 million in two new factories.[18] Plans to set up manufacturing capacities in Europe received an offer from the government of the state of Saxony[19], with the objective of "strengthening Silicon Saxony as a high-tech location",[20] although, in the end, nothing came out of it.

Intel, for its part, has considered setting up a new factory in Europe. While the UK was ruled out because of Brexit[21], the company received financing offers from both Germany, for €6.8 billion, and Italy, for 40% of Intel's total investment in the country[22].

Semiconductor manufacturers ST Microelectronics and Global Foundries likewise announced plans to build a factory in France, also receiving funding of around $5.7 billion.[23]

The investment required to finance foreign initiatives provides the area with autonomy, although it may not respond to the need for the sovereignty that would allow the creation of products with which to gain a relevant place in the international technological market.

The question arises as to whether the establishment in a territory of the production capacity of one of the foreign computing giants will contribute to the generation of strategic value or simply of new products.

The European Union reaction

European Commission President Ursula von der Leyen said that *The European Chips Act will "enable €15 billion ($17 billion) in additional public and private investment by 2030".*[24] This amount must be set in contrast with the investment that private entities are

[18] MARTIN, Dylan. *TSMC's CEO is not pleased with the growing US-China rift* https://www.theregister.com/2022/12/21/tsmcs_ceo_us_china/
[19] MARTIN, Dylan. *Intel to get $7.3b for Germany fab site as TSMC dismisses Europe plans* https://www.theregister.com/2022/06/08/intel_germany_tsmc/
[20] *TSMC in talks with suppliers over first European plant* https://www.reuters.com/technology/tsmc-talks-with-suppliers-over-first-european-plant-ft-2022-12-23/
[21] CLARK, Lindsay. *Intel's €80bn European chip plant investment plan not bound for UK because of Brexit* https://www.theregister.com/2021/10/07/intels_80bn_european_chip_plant/
[22] FONTE, Giuseppe et al. *Exclusive: Italy, Intel close to $5 billion deal for chip Factory.* https://www.reuters.com/technology/exclusive-italy-intel-close-5-bln-deal-chip-factory-sources-2022-08-04/
[23] KAR-GUPTA, Sudip and MUKHERJEE, Supantha *STMicro, GlobalFoundries plan new $5.7 billion French chip Factory*. https://www.reuters.com/technology/stmicroelectronics-globalfoundries-confirm-major-new-france-investment-2022-07-11/
[24] YUN CHEE, Foo and SIEBOLD ,Sabine.*EU eases state aid rules in multi-billion euro boost for chip sector* https://www.reuters.com/technology/eu-lays-out-billion-euro-plan-boost-chip-production-2022-02-08/

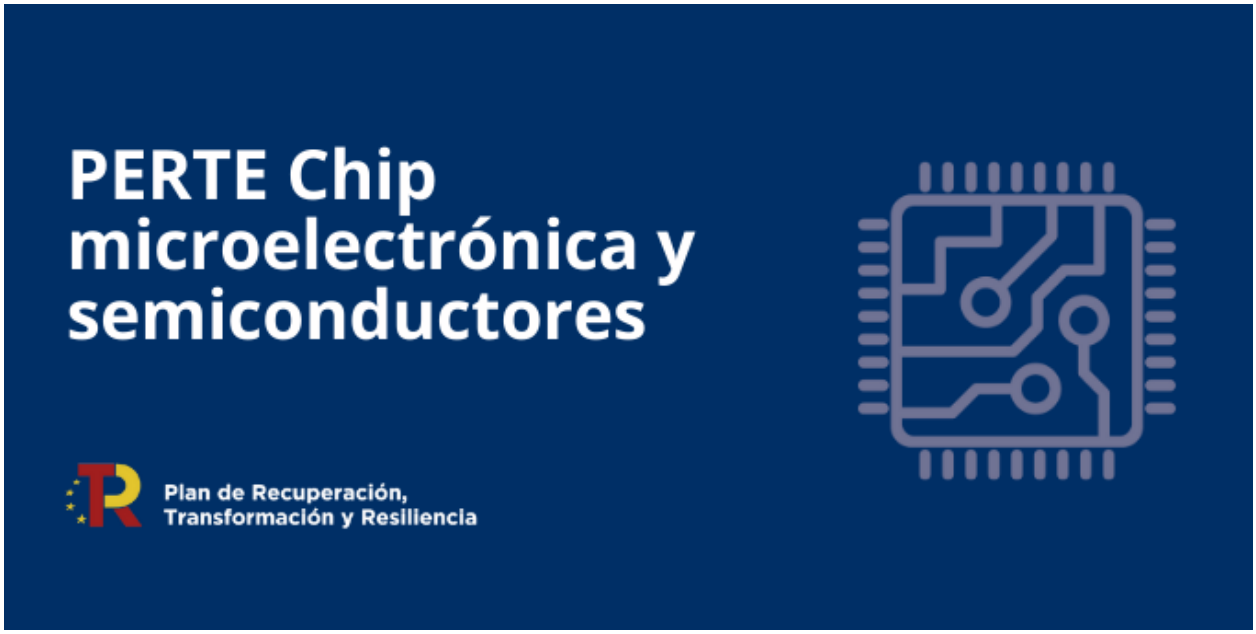
putting on the table for the development of new production infrastructures. However, this amount will face much more ambitious aims:

> *"The European Chips Act establishes a framework to stimulate investment to help meet the 20% global production target by 2030. It is divided into three pillars:*
>
> *- Pillar I. Establish a Chips for Europe Programme to support large-scale capacity development through investment in research, development and innovation infrastructures to strengthen the EU's advanced design, system integration and chip production capabilities.*
>
> *- Pillar II. Create a framework to ensure security of supply by attracting investments and enhanced production capabilities in semiconductor manufacturing, and to advance packaging, testing and assembly through integrated production facilities and foundries.*
>
> *- Pillar III. Establish a coordination mechanism between Member States and the Commission to strengthen collaboration with and between Member States, monitor semiconductor supply, estimate demand, and anticipate crisis situations and shortages".*[25]

And in Spain

Spain is well aware of the importance of microelectronics in today's world and is also taking steps to address its dependence on foreign suppliers. As part of the Recovery, Transformation and Resilience Plan, it has launched the Strategic Project for the Recovery and Economic Transformation of Microelectronics and Semiconductors (PERTE Chip), which aims to both reduce this dependence and to promote a space where knowledge, training and national capacities can be used to generate value, new business models and companies with high technological value.

[25] PERTE Chip Microelectronics and Semiconductors. TECHNICAL REPORT https://planderecuperacion.gob.es/sites/default/files/2022-05/PERTE_Chip_memoria_24052022.pdf



PERTE Chip will be developed around four strategic lines[26]:

- *"Strengthening scientific capacity, with actions to strengthen R&D&I on leading-edge microprocessors and alternative architectures and integrated photonics, to develop quantum chips and to launch a funding line to reinforce the Major Project of Common European Interest (IPCEI) in Microelectronics and Communication Technologies. An investment of €1.17 billion is planned for the period 2022-2027.*
- *Design strategy. Includes actions that will boost Spanish capacity in microprocessor design through the creation of fabless companies (whose designs can be manufactured by others, without the need for their own factory) for the design of cutting-edge microprocessors and alternative architectures, pilot line testing and a semiconductor training network. A total of €1.33 billion will be earmarked for this line.*
- *Construction of manufacturing plants. To achieve domestic semiconductor production capacity in leading-edge (below 5 nm) and mid-range (above 5 nm) technology manufacturing. The budgeted public investment is €9.35 billion.*
- *Stimulation of the ICT manufacturing industry. Envisages actions such as the creation of a chip-focused equity fund to finance startups, scaleups and innovative SMEs in the domestic semiconductor sector, with an initial public endowment of €200 million. Also aimed at strengthening domestic production in electronics*

[26] PERTE Chip Microelectronics and Semiconductors. TECHNICAL REPORT https://planderecuperacion.gob.es/sites/default/files/2022-05/PERTE_Chip_memoria_24052022.pdf

manufacturing - which uses microchips as an input - to act as a tractor sector for the semiconductor industry and to absorb part of its output. The estimated budget amounts to €400 million."

All this involves the mobilisation of €12.25 billion in public investment up to 2027[27], financed by European funds. Public-private collaboration will be an essential mechanism for carrying out these actions, the intention of which is to take advantage of Spain's position in the development of alternative architectures such as RISC-V, integrated photonics and the development of quantum chips.

SMEs have also received priority attention with the creation of a specific fund, initially endowed with €200 million, to finance *startups* and *scaleups*.

Conclusions

The international cooperation that for so many years has been shaping the phenomenon of globalisation is breaking down in the shift towards new strategic paradigms in which the differences between actors are increasingly relevant. There is declared competition, the roots of which penetrate deep into the very foundations of societies which, for many years, have to some extent renounced their principles, guided in many cases by economic decisions. However, this resignation is being forgotten vis-à-vis evidence that a new international order appears to be possible. Conflicts that have been hibernating for years are beginning to gain momentum as technological developments and political needs for local support are changing the tilt of the balance of power.

Efforts to maintain multilateralism and globalisation are outweighed by practices in the completely opposite direction, where clear demarcations are drawn, restrictions are imposed on the traffic of goods and services between territories, and there is direct competition for hegemony, either alone or in coalition. In this context, conflicts become indicators of the preponderance of one actor over another, with positions of strength that threaten international peace and stability.

These actions are not without consequences that impact on the *status quo* and on political, economic and social stability. The degree of optimisation previously achieved

[27] https://planderecuperacion.gob.es/como-acceder-a-los-fondos/pertes/perte-de-microelectronica-y-semiconductores

over the years, resulting in tight pricing by means of carefully considered processes and the removal of barriers, is giving way to a more turbulent environment with additional costs to cope with the new constraints imposed.

Large companies have emerged as a result of globalisation which support states in their actions, and whose size and positioning limit the capacity of other less active actors to return to the path that leads to sovereignty or limited dependence. The effort required to reach anywhere near a comparable level to that of the big players is not only an economic issue but requires considerable political and social support.

Due to its relevance in current and future technological development, microelectronics, as this paper shows, has become one of the tools used in the power conflict. The risk of confrontation is ever increasing, and in conflict situations history shows how technological superiority has almost always been a winning strategy.

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