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Global Semiconductor Trends and the Future of EU Chip Capabilities

European Strategy and Policy Analysis System

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SUMMARY

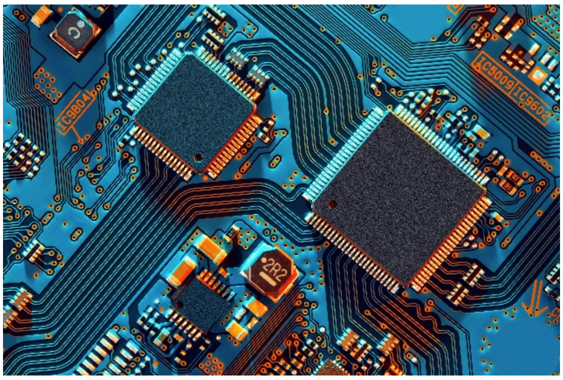
The proposed European chips act, presented by the European Commission in February 2022, aims to mobilise €43 billion in 'policy-driven investment' for the EU's semiconductor sector by 2030. The Commission expects long-term private investment to exceed this. The plan serves to enable immediate EU coordination against supply disruptions, strengthen and scale up production and innovation throughout the EU semiconductor value chain, and further enhance the Union's technological leadership, practical applications and digital sovereignty in this crucial field.

The global semiconductor value chain is characterised by chokepoints and critical dependencies, including on more advanced chips from Taiwan and South Korea, US intellectual property in chip design automation, Japanese wafers and Chinese chip assembly. Europe has strong capacities in research and equipment manufacturing, in addition to some production capacity of (less advanced) chips with larger transistors, often destined for the automotive sector, as well as (chemical) inputs.

The semiconductor supply shortages that emerged during the pandemic are unlikely to dissolve soon as huge amounts of capital and knowledge are needed to ramp up production. Investment in innovation remains key and European research remains a driving force in the progressive miniaturisation of increasingly advanced and efficient chips. The rapid vertical and horizontal expansion in chips applications means the market for semiconductors is expected to double from US$550 million presently to over US$1 trillion by 2030.

In response to this trend, the US and Japan announced investment plans worth US$52.7 billion and US$6.8 billion to attract advanced chip manufacturers including Taiwan's TSMC to come build production facilities. China reportedly provides US$97 billion in national and regional funds for 2014-2024, and South Korea uses tax reductions and other measures, both in efforts to attract another US$225 billion and US$450 billion in Chinese and Korean investments over a 10-year period. Taiwan's chip giants are expanding their foreign assets and are building production facilities in the US and Japan. Talks and mutual expressions of interest suggest Europe could be next.

The insights shared by consulted policy experts allow us to imagine four potential futures for EU semiconductor interests towards the end of this decade. Their expectations, hopes, fears and geopolitical insights here shape the potential continuity, rise, decline and collapse of EU semiconductor capabilities and supply security by 2030, as well as key policy questions to consider.



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Author: Kjeld van Wieringen

The European Chips Act

The proposed European Chips Act, presented by the Commission in February 2022, aims to mobilize €43 billion in 'policy-driven investment' for the European semiconductor sector by 2030. The Commission expects long-term private investment to exceed this. The plan serves to enable immediate European coordination of responses against supply disruptions, strengthen and scale-up production and innovation throughout the European semiconductor value chain, and enhance Europe's technological leadership, practical applications and digital sovereignty in this field.

The European Chips Act is structured in three main pillars:

- The Chips for Europe Initiative, targeting research: The **Chips Joint Undertaking**, a strategic reorientation of the Key Digital Technologies Joint Undertakings under the Horizon Europe and Digital Europe programmes, will pool €11 billion from the EU, Member States, partner countries and the private sector to strengthen existing research, development and innovation.
- Security of supply, targeting enterprise: A Chips Act Regulation will provide a framework to improve the security of supply by attracting investment in advanced production capabilities and related innovations. A €2 billion **Chips Fund** would facilitate access to finance for start-ups to propel innovations and attract investors. Further capital would be attracted through a semiconductor equity investment blending facility under InvestEU to support scale-ups and market expansion by SMEs. Provisions furthermore support **first-of-a-kind facilities** categorized as 'Open EU Foundries' which design and produce semiconductor components mainly for other industrial players and 'Integrated Production Facilities' which design and produce components for the European market. Support comes in the form of fast-track permits, prioritised access to pilot lines and relative leniency concerning state aid rules when offered public support by Member States. Another €30 billion in public and private investments would accompany this.
- Monitoring and crisis response, targeting coordination: A **coordination mechanism** between Member States and the Commission will monitor the supply and value chains of semiconductors, estimate demands and shortages, gather intelligence from companies and identify critical weaknesses and bottlenecks. It will feed into a common crisis assessment and coordinate actions to be taken from a new emergency toolbox.

The Chips Act would serve to achieve various outcomes throughout the projected timeframe:

Short term	Medium term	Long-term
Enable immediate coordination to put in place crisis response measures.	Strengthen and scale-up manufacturing and innovation throughout the value chain, improving security of supply.	Maintain European technological leadership and enhance its application in production and innovative downstream markets.

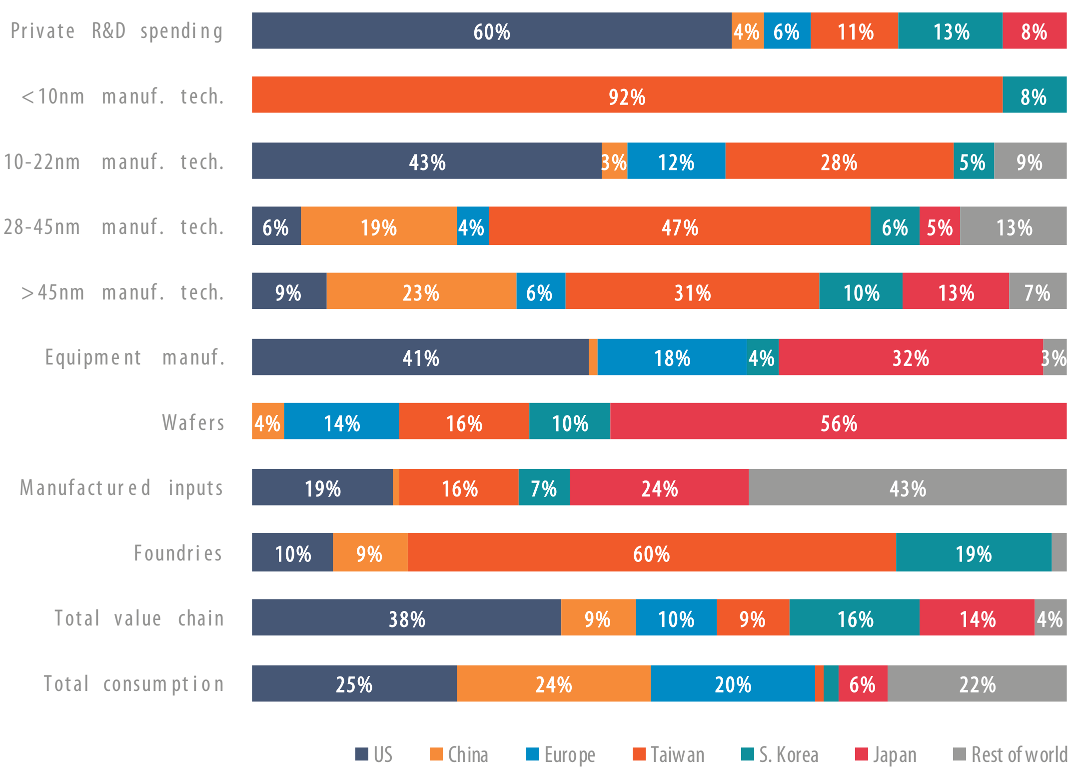
The Commission outlined that the Chips Act has been developed in response to the global shortages during the pandemic that dramatically exposed the vulnerabilities in the semiconductor supply chain and the vital role of chips in modern economies. Semiconductor value chains are characterized by exceptional globalized complexity and cross-border dependencies. Various players in the EU, US and East Asia are engaged in an industrial race, featuring both competition and cooperation, to attain a better position in the global semiconductor value chain. The Commission also emphasized the need to better understand global semiconductor value chains if the EU is to reinforce its capacities and supply security in this crucial field. This paper accordingly reviews Europe's current position and long-term challenges in the global semiconductor value chain by analysing existing interdependencies and capabilities, key global industry and policy trends, and potential futures for EU semiconductor capabilities and supply security.

The EU's position in the global semiconductor value chain

International interdependencies

Under 10 % of global semiconductor production occurs in Europe, which is limited to the larger, so-called trailing-edge chips (at 22 nanometres and above). Only two companies in East Asia, TSMC in Taiwan and Samsung in South Korea, are capable of manufacturing so-called cutting-edge chips (at 2 to 7 nanometres), while the necessary equipment for that production is produced solely in Europe, by ASML in the Netherlands. The EU's share of global chip revenues has gone down from 20 % in the 1990s to 10 % presently. Without rapid and significant investments, the EU's global market share would drop to below 5 %, putting its industrial competitiveness and technological autonomy further at risk. A severe disruption in the supply chain could deplete Europe's limited chip reserves within a few weeks, grinding many European industries to a halt.

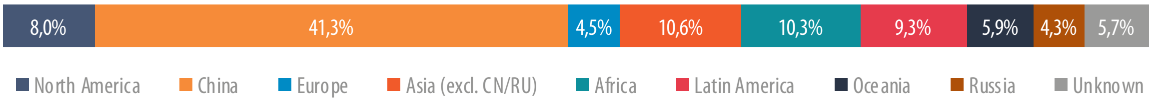
Figure 1 – Global semiconductor market shares



Data source: Center for Security and Technology and Semiconductor Industry Association.

Mutual dependence will persist. **No country is self-sufficient** when it comes to semiconductors due to the complexity, geographic specialisations and **deep interdependencies** characterizing the supply chain. Figure 1 above and figure 2 on the next page for instance indicate that the US dominates global private R&D spending, Taiwan the foundries and most advanced manufacturing technology, Japan wafer fabrication, and China raw material inputs. Chip making, from design to production, assembly, testing and packaging is comprised of over 1 000 steps using around 300 materials including silicon wafers, gases and chemicals. Large semiconductor producers rely on up to 16 000 suppliers worldwide. A supply chain crosses the border 70 times before reaching an end user and over 50 choke points where one region holds more than 65 % of the global market share. This makes the supply chain vulnerable to disruptions such as natural disasters, infrastructure failures and geopolitical tensions.

Figure 2: Semiconductor raw material market shares

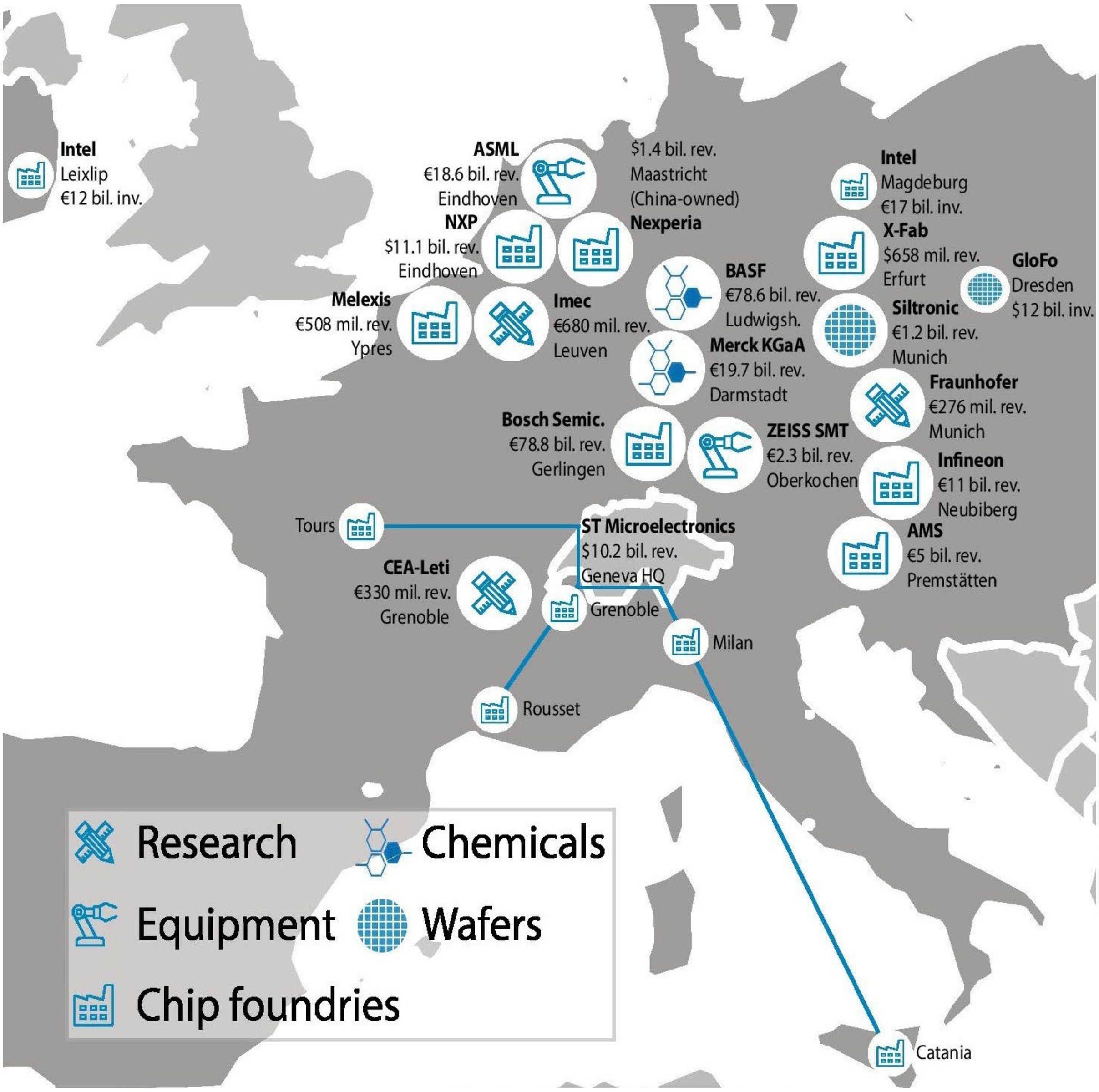


Data source: Center for Security and Technology

European semiconductor assets

Europe is home to world leading semiconductor organizations, including ASML in the Netherlands, the only company that builds the equipment used by TSMC and Samsung able to produce the smallest chips, and innovative research facilities including Imec in Belgium, Leti in France and Fraunhofer in Germany. Multiple European semiconductor manufacturers, often specialized in supplying Europe's automotive, healthcare and industrial equipment sectors, are also present. German companies also have significant market shares in supplying advanced chemical inputs and wafers for semiconductor production (see figure 3 below).

Figure 3 – Major European semiconductor assets, annual revenues and FDI



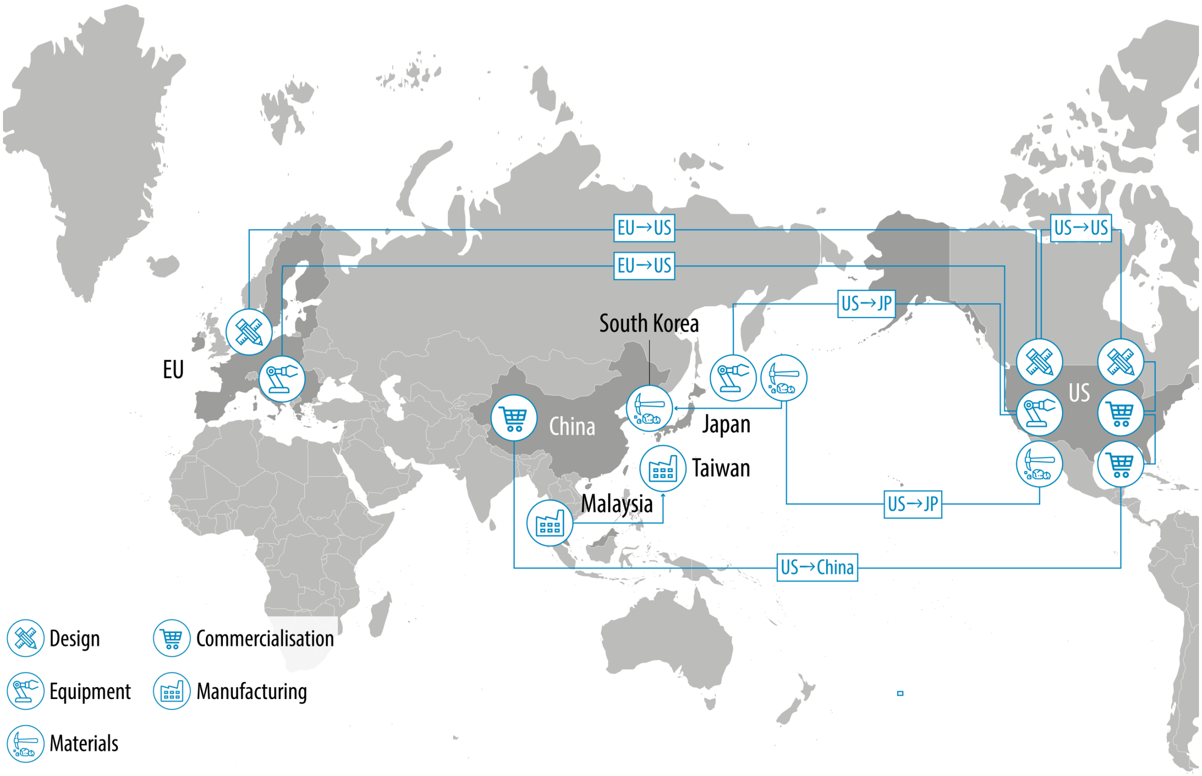
Source: Map compiled by author with latest annual revenues (budgets for research centres) reported online

Global industry trends

Supply chain disruptions

European car manufactures were hit especially hard by factory-shutdown related chip shortages during the pandemic. In early 2020 they cut back chip orders due to falling demand and chip foundry (factory) capacity was reallocated to IT equipment makers. Once car orders picked up by the end of the year, foundries were already running at full capacity, leaving automakers with long waiting times of up to a year or more. As a result, car factories were shut down across Europe and workers laid off. According to the Commission's communication, 11.3 million cars could not be produced globally in 2021 due to the shortage and some Member States saw their car production drop 34 % from 2019 figures, back to 1975 levels. Industrial equipment producers suffered just as much. In other sectors, delivery of healthcare devices was delayed, consumer electronics went out of stock, and even security, defence and aerospace sectors were threatened by shortages. Following the shortages, European car manufacturers called for increased EU chip production and reduced reliance on imports.

Figure 4 – Global semiconductor supply chain



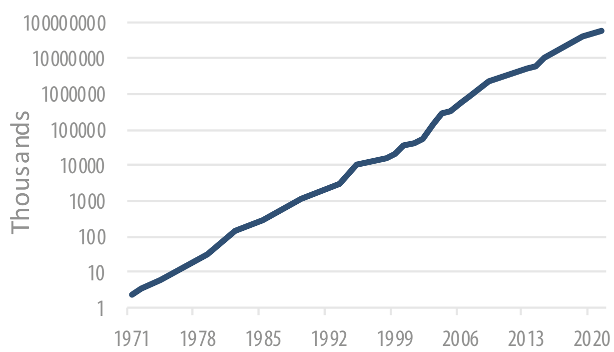
Source: EPRS.

Current shortages have resulted mainly from a combination of rapidly **growing demand** (a trend that existed pre-pandemic but surged owing to skyrocketing IT equipment sales during the lockdown), **long manufacturing cycles** colliding with just-in-time production models of users, **supply inflexibility** adapting poorly to economic developments during the COVID-19 crisis, temporary semiconductor **factory closures** because of the pandemic and natural disasters, supply chain issues caused by **pandemic-related transport restrictions**, and **geopolitical tensions**. Shortages are unlikely to dissolve by 2023 or even 2024 as demand keeps rising, while scaling up production requires considerable time and effort. Considering these issues, **the EU should evaluate whether its tools** apart from the Chips Act, including its strategies (e.g. the Global Gateway), partnerships and infrastructure (e.g. ports), **are fit for the purpose of providing semiconductor supply security in the years to come**.

Miniaturisation and market growth

Semiconductor production is knowledge and capital intensive. Hardly any other industry invests more of its returns in research and development (R&D). A foundry producing the most advanced chips costs around US$20 billion. Running it could require as many as 2 000 semiconductor engineers and thus a robust local talent pool. The Commission has stressed Europe's world-leading position in technological innovation and equipment manufacturing in the semiconductor field. European research is a driving force behind the miniaturisation of chips, which is key to rapid technological evolution within the sector. According to Moore's Law, every two years technological advances will roughly double the number of transistors per area of semiconductors, and therefore also the computing power and energy efficiency of the most advanced chips of the same size. Leading-edge chips now fit tens of billions of transistors on one square centimetre of silicon, compared to only dozens for the earliest chips in the early 1960s and thousands in the 1970s.

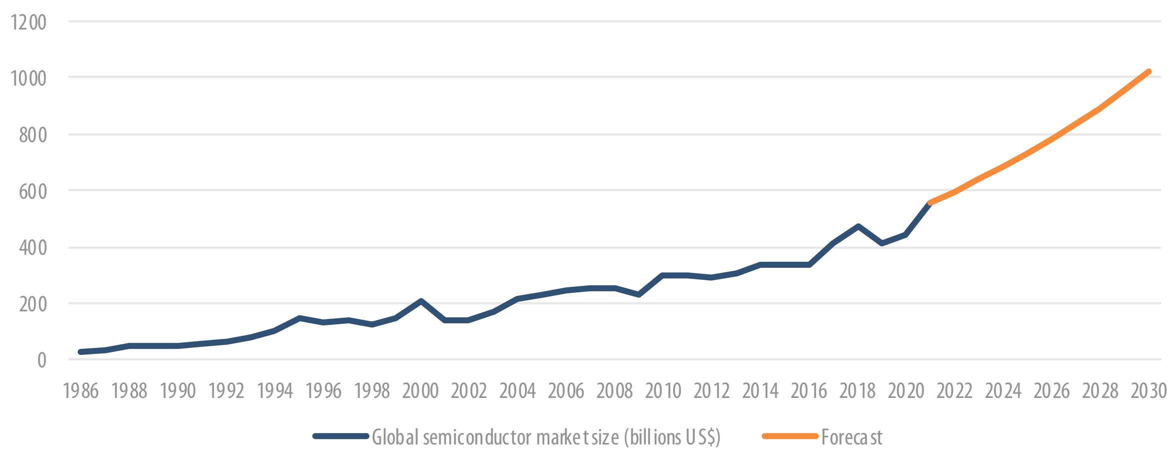
Figure 5 – Transistors per microprocessor



Data source: Karl Rupp, 42 Years of Microprocessor Trend Data, found via Our World in Data.

Semiconductors have been described as being for the digital transition what steam engines were for the industrial revolution: a general purpose technology that defines a whole era of economic growth and progress. Chips are universally present and essential components of digital and digitised products, devices and infrastructures, from smartphones and vehicles to healthcare, energy, communications and industrial facilities. With the digital transformation and the emergence of highly automated cars, the internet of things, AI, cloud-, edge-, and quantum computing, supercomputers, industrial production automation, and applications in space and defence, chips will only grow more crucial as **economic and strategic assets**. With the relentless expansion of **computing capacities, AI and connectivity**, including the need to manage ever growing data volumes and the widening digitalisation of electrical devices, industrial machines, and vehicles, the **market for semiconductors is expected to double** from US$550 million currently **to over US$1 trillion by 2030**. It is therefore fundamental for the EU's future open strategic autonomy, digital sovereignty, and competitiveness vis-à-vis other players for it to reinforce its technological capabilities, industrial capacity and supply security in the field of semiconductor.

Figure 6 – Global semiconductor market growth



Data source: World Semiconductor Trade Statistics and McKinsey's projected yearly growth.

Global policy trends

United States

Other players on both sides of the Pacific are implementing their own plans to reinforce their domestic semiconductor capacities, thus further indicating the need for European action to keep up. The EU Chips Act will mainly have to compete or find synergies with existing investment strategies in the US and East Asia. Across the Atlantic, the US will spend **US$52.7 billion** in subsidies on the US semiconductor industry for 2021-2026 as part of its CHIPS Act that was signed into law by President Joe Biden in August 2022. US$39 billion of this financial assistance will flow towards semiconductor manufacturing facilities while the rest is reserved for R&D and workforce programs (US$13.2 billion), automobile and defence (US$2 billion), and international technology security and semiconductor supply chain activities (US$500 million). The policy also includes a 25 % tax credit for investments in US semiconductor facilities and a ban for beneficiaries to expand chip manufacturing in China. US officials argued at the time of the act's passing in Congress in 2021 that this funding could lead to the construction of 7 to 10 new semiconductor US-based factories in the next five years. With the help of these funds the US has managed to attract investments by South Korea's Samsung, which is planning to build a US$17 billion foundry possibly in Texas, and Taiwan's TSMC, which has a US$12 billion foundry planned in Arizona, in addition to Intel's US$20 billion investment for two new foundries in the same state. This is in addition to the very substantial private investments in innovation taking place in the US semiconductor sector. US semiconductor corporations spend US$39.8 billion in R&D in 2019, over half of the world's total, compared to only US$2.6 billion spend on R&D by Chinese semiconductor firms in 2018.

US export control measures against China have aimed to isolate China's semiconductor ecosystem from foreign technology and inputs. The US has attempted to pressure but not yet successfully forced the most advanced producers, TSMC in Taiwan and Samsung in South Korea, to cut off Chinese customers, and is trying to block European semiconductor equipment manufacturer ASML from doing business with China as well. US alarm about China's growing competitiveness in the semiconductor sector and civil-military fusion approach in technological development is gaining ground, indicating that political pressure including export controls targeting Chinese semiconductor firms will likely only grow in the future. Semiconductor firms worldwide are increasingly forced to at least make the appearance of picking national sides.

US chip giant Intel recently announced €33 billion in investments in semiconductor facilities across Europe as part of an €80 billion investment strategy to strengthen the European semiconductor value chain during this decade. These investments serve to double the manufacturing capacity an existing foundry in Ireland (€12 billion), to build two 'first of a kind' foundries in Germany's Magdeburg (€17 billion) to be operational by 2027, an R&D hub and chip foundry design centre in France, semiconductor-related AI and supercomputing laboratories in Poland and Spain, and the acquisition of a foundry in Italy. Negotiations with the Member States concerning government funding for the investment plan have been ongoing since March 2021. Hailed by Commissioner Thierry Breton as the 'first concrete outcome of the EU Chips Act', **Intel's investment plan seems to demonstrate vast synergies between the European and US semiconductor industries and the great potential for further investment cooperation.** If Intel follows through on its intention to invest €80 billion in Europe this decade, that would be almost double the €43 billion long-term private investments towards 2030 that the Commission expected would accompany the Chips Act.

Intel's vice president of European government affairs expressed that while the European Chips Act comes after the US' equivalent, its faster legislation process, expedited permitting for quick semiconductor facility construction and provisions to address supply disruptions provide significant advantages over the US Chips Act. Intel's director of security and technology policy and vice president of global regulatory affairs suggest that, spurred by both semiconductor initiatives, collaboration between the US and EU to realize their chip ambitions and jointly tackle breakthrough challenges could make semiconductors a testbed for intensified relations, even ushering in 'a new era of effective transatlantic cooperation'.

China

The Commission reports that China is investing an estimated US$150 billion in its semiconductor sector for the period 2015-2025. In 2014 China issued the National Integrated Circuit Industry Development Outline to improve centralized policy coordination on semiconductors. The outline set development targets throughout the semiconductors value chain to be achieved through direct financing, including national and regional investment funds, and tax relief measures. It included a dedicated national investment fund (i.e. Big Fund) worth approximately US$20 billion in central public funds for 2014-2019 (Phase I), investing two-thirds in manufacturing, 20 % in chip design and 10 % in assembly, test and packaging (back-end), but also attracting about US$75 billion from other financing sources for that period according to Chinese state media. From October 2019 to 2024 (Phase II), China's public Big Fund disposes of over US$32 billion and aims to attract five times that, over US$150 billion, in additional investments. As of mid-2020 fourteen province-level governments have set up regional semiconductor investment funds together worth around US$45 billion. Put together this would raise China's use of public semiconductor funds to a total of **US$97 billion** for 2014-2024, with additional attracted investment expected reach US$225 billion over the same period. While huge sums of state-led funding may be wasted due to inefficiency or the crowding out of private investment, abundant public aid will likely be a net benefit to the sector as lacking investment has been a major development constraint in the past.

The Made in China 2025 industrial upgrading plan, issued in 2015, aimed to reach 40 % self-sufficiency in semiconductors by 2020, and 70 % by 2025. This is in stark contrast to China's estimated 16 % semiconductor self-sufficiency as of 2020, far below the original but now unsurprisingly rarely cited target. Corruption reportedly has been one factor in causing the disappointing results of China's massive chip investments. The Communist Party's growing impatience with this lack of performance has been indicated by the arrest, seemingly on corruption charges, of a dozen top officials and executives in charge of China's push for chips, including the head of the Big Fund.

China remains especially deficient in R&D capacity and human talent. Greater resources for innovation and exchanges with leading firms and experts, as well as talent-poaching targeting Taiwanese and South Korean companies, serve to mitigate this gap. Retaining talent also remains a problem, as indicated by the preference of most students from Tsinghua University's newly established semiconductor school to continue studying and working in the US. Decoupling pressure from the US and its allies may push China to move away from the fast-follower strategy, a market-guided track with a proven record in Taiwan, South Korea and Japan in which players initially focus on lower-value added positions in the global supply chain and gradually build up leverage. The riskier alternative, which seems to feature more strongly than before in China's 14th Five-Year Plan for Science & Technology Innovation of 2021, would be technological leapfrogging in emerging markets, or in Chinese phrasing to "change lanes and overtake others" including in anticipation of the post-Moore era. As in other sensitive domestic sectors and due to geopolitical trends including US decoupling pressures, supply chain security is quickly gaining ground on market mechanisms in Chinese national and regional strategies to further develop China's semiconductor ecosystem.

Unfortunately for its foreign competitors and despite its failure to reach previously set targets, China's progress in both the quality and quantity of its domestic chip production is becoming increasingly apparent. China's largest chip manufacturer SMIC is reportedly close to producing advanced 7 nanometre chips down from 14 nanometres in the past, despite US export restrictions which may have slowed down but failed to block those technological advancements. While some have nuanced this reported break-through by indicating the massive hurdles before mass production becomes possible, it is nonetheless seen as a wake-up call for the US and others not to underestimate China's technological progress in semiconductor manufacturing. China will also be building up to 31 trailing-edge chip foundries by 2024, as much as the US and Taiwan combined. Some suggest this rapid upscaling of a highly subsidized Chinese trailing-edge "fab sea" risks to undercut foreign chip prices and to put enormous pressure on foreign competitors that are producing such less advanced chips elsewhere in the world. Half a year after start of the war in Ukraine and related sanctions, access to chips has reportedly become the main bottleneck for Russian military equipment and procurement while Chinese chip exports to Russia have more than doubled, further indicating the geopolitical significance of China's push for increased semiconductor production.

Despite persistent inefficiencies and weaknesses, China's position across the entire semiconductor value chain has significantly improved compared to ten years ago. China will further intensify its efforts during this decade. **In the absence of an effective response, Europe will fall increasingly behind and become dependent on China for wafer fabrication, back-end (assembly, test and packaging), raw materials including chemicals, and even technology**. Heavily subsidized Chinese input suppliers could rapidly displace European industries, as happened with the solar sector. China will not move to autarky, which is considered impossible in the semiconductor sector. It will instead try to shape the globalization of the industry on terms that are increasingly favourable to Chinese interests. This would feature Chinese leadership in key segments of the global supply chain and would inevitably pose challenges to various related EU interests.

South Korea

In May 2021 South Korea unveiled a plan in which 153 companies will spend US$450 billion in investments in the country's semiconductor industry by 2030, facilitated by the government through tax breaks, low-interest loans, eased regulations, improved supporting infrastructure and support to train 36 000 chip experts. The blueprint provides 10-20 % tax deductions for semiconductor facility investment and 40-50 % for R&D, compared to the previous 3 % deduction rate. South Korea is home to Samsung Electronics, the most advanced chip producer after TSMC. Samsung is increasing its spending by 30 % to US$151 billion for this period. Hynix, another South Korean chips giant, will invest US$97 billion to expand existing facilities plus US$106 billion for four new plants. An industry survey indicated that Korean chipmakers will invest an estimated US$47.4 billion in the sector during 2022, a 10 % increase over 2021 on par with estimates for global increases in chip manufacturing.

South Korea is the world's leading supplier of memory chips, meaning semiconductors that handle storage. This constitutes around 20 % of total national exports. But it lags behind in logic chips, which handle calculations, of which Taiwan, the US and China own a larger market share. South Korea is competitive throughout the value chain, from design to manufacturing, packaging and marketing. A complete semiconductor ecosystem integrating all these value chain steps is densely packed into a 60 km corridor stretching from Seoul to Pyeongtaek. The government seeks to expand this "K-semiconductor Belt". South Korea's Ministry of Trade has likened chips to rice, an essential staple, and referred to them as "strategic weapons". The government's target is to double South Korean semiconductor exports to US$200 billion in ten years and, in the president's words, to ensure that South Korea will remain a "semiconductor powerhouse" and "take the lead globally" for both main chip types. The policy's success will in large part be determined by its long-term consistency and continued momentum, as previous administrations announced many related strategies which fizzled out with each new government.

Japan

In November 2021 Japan approved US$6.8 billion in government funding for the domestic semiconductor industry. 80 % would be invested in chip manufacturing capacity, 14 % for R&D in next-generation silicon (in line with Japan's dominance in silicon wafer fabrication), and 6 % in other areas. US$3.5 billion of the first segment will go towards funding half the construction costs of a planned semiconductor foundry to be built by TSMC and Sony at Kumamoto in southern Japan which is scheduled to start operations in 2024. Other parts will go to subsidizing the expansion of existing foundries. The chips fabricated at the new TSMC plant will not be more advanced than those manufactured a decade ago. This has invited criticism among stakeholders that Japanese semiconductor ambitions would fail to go beyond avoiding chip supply shortages to also secure Japan's future technological competitiveness in the sector.

Taiwan

Taiwan owns 63 % of the global semiconductor market share. The Taiwan Semiconductor Manufacturing Company (TSMC) alone holds 54 % of the world's market share and 84 % of the pure foundry revenue of chips below 10 nanometres, compared to 14 % by Samsung, as of 2020. Taiwanese semiconductor companies previously showed reluctance in opening overseas foundries due to fears of creating a more competitive outside market, potential technology leaks or transfers, and the difficulty to replicate the Taiwanese formula abroad due to its reliance on the industry cluster in Hsinchu Science Park. The latter's abundant, relatively affordable, hard-working, highly skilled and specialized workers and its other facilities makes establishing foundries in Taiwan an estimated six times cheaper compared to building them abroad. In efforts to meet future talent demands the Taiwanese semiconductor industry is investing heavily in its chip schools.

Despite such obstacles related to competition, scale and cost-efficiency, **TSMC became actively engaged in expanding its ventures abroad from 2020 onwards**, especially in Japan (US$8.6 billion) and the US (US$12 billion). The need for TSMC to diversify supply chains in order to mitigate the risk of potential disruptions threatening the island, including earthquakes and especially a Chinese military aggression, finally pushed the company to accelerate the search for opportunities beyond Taiwan. Experts claim that TSMC is shifting production abroad to ease the catastrophic effect on the global economy of a potential Chinese attack or blockade cutting off the supply of chips from "possibly the most important company on the planet" to the rest of the world.

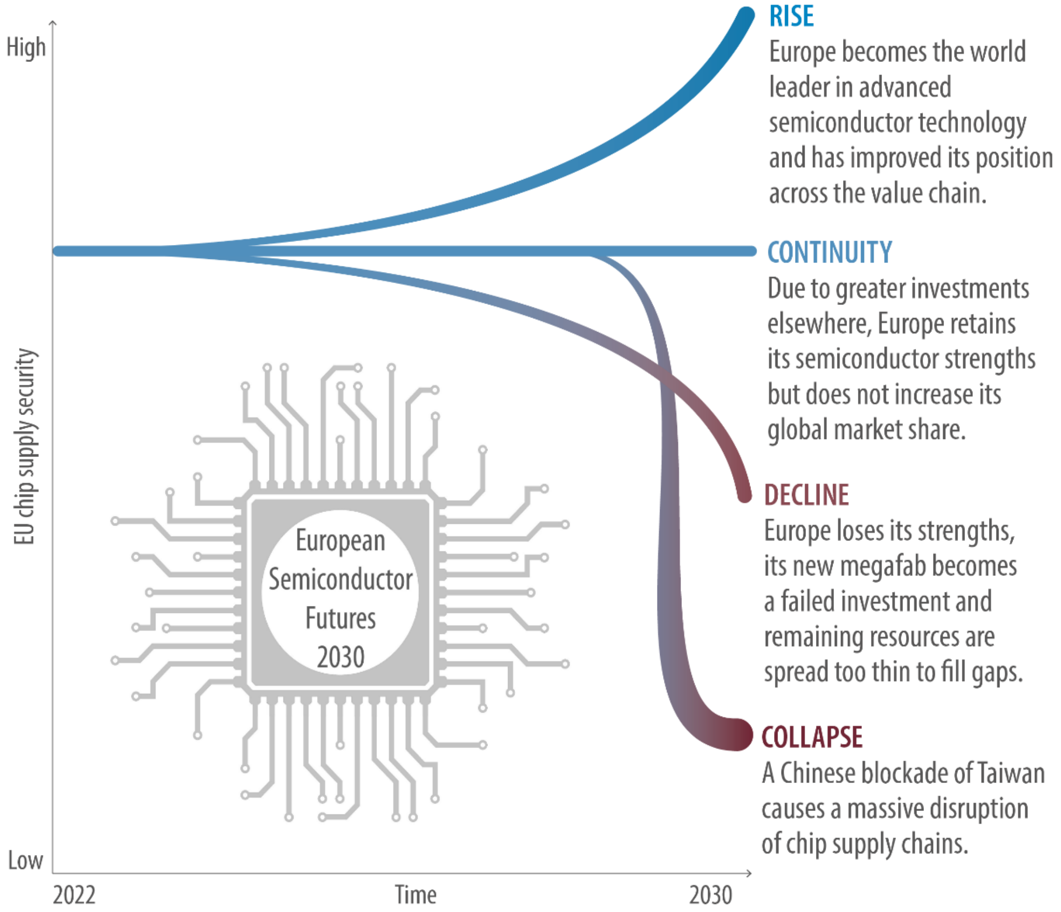
Preliminary talks have been held with the German government, which seeks to attract part of the US$44 billion in investments that TSMC has scheduled for 2022. European Commissioner Thierry Breton has also met with TSMC executives in the past and implied that the EU will work to bring TSMC to Europe. As of 2020, Taiwanese investments in the EU's semiconductor sector have totalled over €4.35 billion and in August 2021 TSMC expressed its intention to establish its first European semiconductor foundry. Europe's advanced semiconductor research facilities, equipment manufacturer ASML and demand from car manufacturers could make the EU a favourable destination for future Taiwanese chip production, especially if subsidies are competitive compared to those offered by Japan and the US.

TSMC reported in 2019 that exports to the US account for 59.3 % of its annual revenues, while China accounted for 19.4 %, resulting in a need to hedge between the two powers. Diversified international semiconductor cooperation, with alternative partners such as the EU, has been identified as a strategy for Taiwan to strengthen its resilience, improve its geopolitical position and mitigate its dependence on China, the US and their ongoing rivalry. The attraction of the Taiwanese semiconductor industry is a powerful diplomatic tool, as also indicated by Taiwan's pledge to invest US$200 million in semiconductor cooperation with Lithuania to reward the country for its support to Taiwan. Taiwan's foreign minister Joseph Wu expressed that cooperation with Lithuania could serve as an entry to the rest of the European semiconductor market. The EU Chips Act was also welcomed by Taiwan as an opportunity to enhance such cooperation. Europe remains keen to draw in Taiwanese chip investments and cooperate on supply chain security. In this context, the first EU-Taiwan high-level trade and investment dialogue took place between director for trade Sabine Weyand and the Taiwanese minister for economic affairs Wang Mei-hua on 2 June 2022.

Potential futures for 2030

The following four potential futures for the EU chip capabilities and Europe's position in global semiconductor value chains by 2030, and the questions for policymakers at the end, have been developed through an interactive process involving a survey, workshop and conversations with over a dozen engaged policy experts working in this field.[1]

Figure 7 – Potential EU semiconductor futures for 2030



Source: EPRS design with scenarios from survey, workshop and exchange with semiconductor policy experts

[1] Most insights in this section were gathered from the input shared through a survey and workshop organized on 23 June 2022 to which 10 key policymakers and experts working on and closely following the Chips Act participated, namely three European Parliamentary Assistants (of the Chips Act's rapporteur and two shadow rapporteurs), ITRE's designated administrator, three experts from the Commission (DG CNECT), one expert from the Council (ART) and two external participants from industry (ASML) and research (Imec). The first potential future (Continuity) is based on participants' expectations for 2030 as shared in the survey (which 7 of the 10 participants filled out). The second and third potential futures (Rise and Decline) are based on participant's hopes and fears for 2030 as shared in the survey and discussed during the workshop. In contrast to these EU-focused narratives, the fourth potential future (Collapse) explores a sudden external geopolitical disruptive event. It was developed separately in conversation with three leading experts on the interplay between geopolitics and chips, namely John Lee, director of East-West Futures and previous senior analyst at MERICS, Jan-Peter Kleinhans, project director for technology and geopolitics at Stiftung Neue Verantwortung (SNV), and Julia Hess, project manager at the same program. Here, the case of a blockade hitting Taiwan causing a supply disruption was chosen because of Taiwan's critical position as both the main source of semiconductors produced in the world and the scene of major geopolitical tensions in the region. One month after these consultations took place, China's 'dry run' of a blockade of Taiwan in response to US House Speaker Nancy Pelosi's visit to Taipei in early August 2022 further demonstrated the relevance of this scenario. The considerations for policymakers at the end are based on key factors for EU semiconductor success by 2030 that were also identified through the survey and workshop.

1. Continuity

By 2030, Europe's share of global chip production will not be doubled despite the adoption of the EU Chips Act but will rather be at similar levels as now in view of greater investments elsewhere. Europe will have increased manufacturing capacity for leading edge chips to some extent but not greatly due to the continuing lack of European industrial end-users. However, Europe will have strengthened its global market position in advanced semiconductor technologies. Europe will remain a global leader in equipment, (chemical) inputs, automotive chips and research for innovative chip design and applications. EU climate and sustainability goals helped to support European excellence in these fields.

2. Rise

By 2030, Europe will be the world leader in R&D for cutting-edge semiconductor technologies, dominating chip innovation in new fields such as 6G, AI, cloud-, quantum- and edge computing and self-driving cars. Europe dominates the equipment and design segments and has further increased its global market share in chemical input production. Through its unparalleled technological IP development as a world-class innovation hub, Europe creates new markets for microelectronics. Europe leverages its market dominance in semiconductor equipment production and has mitigated some of its critical dependencies on foreign chokepoints in the global semiconductor value chain through diversified international partnerships. Europe manages to foster, attract and retain local and global talent and skilled workers to its semiconductor production and design ecosystem through favourable mobility conditions, tax benefits and competitive wages. This is further reinforced by cooperation between the EU, Member States and industry to provide education, traineeships and scholarships to draw in students and build a skilled workforce according to pre-identified technical needs within the semiconductor sector. Surges in private investment in the Europe's chips sector, facilitated by EU investment blending platforms that manage to attract even the more risk-averse investors, provide the capital needed to fund the expanding innovation by Europe's centres of excellence and scale-ups among SMEs and start-ups. Europe has also managed to attract leading foreign chip manufacturers to invest in it, thus seeing the emergence of green and state of the art chip megafabs in Europe. At least some production capacity will be available on European territory at every part of the semiconductor value chain. EU chip revenue now accounts for over 20 % of the world's semiconductor value chains. Through its pro-active efforts in global value chain monitoring and international R&D collaboration, Europe has led the way in fostering semiconductor partnerships among democratic allies across the world.

3. Decline

By 2030, the EU's position in the global semiconductor value chain has become weaker and more insecure due to the loss of strengths, the failure to fill gaps, wastage of resources and sporadic disruptions of access to foreign-produced chips. A growing lack of EU semiconductor manufacturing and design capacity has caused a large wave of emigration of young talent from the continent. Unfavourable migration policies have also exacerbated the failure to attract and retain new talent from abroad. R&D has slowed down and knowledge drains out of Europe as certain key research facilities have opted to relocate abroad. Others were compromised by third country industrial espionage, which caused distrust and isolated Europe from international R&D collaboration and IP sharing. The lack of talent, high manufacturing costs and regulatory barriers choking the industry have motivated key Western chip manufactures and start-ups to opt to invest and establish facilities in the US and Asia instead of Europe. Europe has lost market shares among production segments previously considered its strong points, including in the manufacturing of equipment, input materials and automotive and other types of chips (such as power, microcontrollers and sensors). Due to its lacking talent and reduced innovation capacity, Europe fails to catch market trends, to capture new user markets and lead the new semiconductor design wave in upcoming digital fields such as edge computing. With its centres of excellence weakened, Europe now risks falling behind on every aspect of the semiconductor value chain. At the same time, global geopolitical tensions, natural disasters and potential pandemics frequently risk to cut off European industries of crucial chip imports. A new partially EU-funded semiconductor megafab failed to meet expectations and became economically unviable due to serious technical problems, environmental issues and lacking demands for its chips. Similar foundry investments across the world caused global semiconductor manufacturing overcapacity and crashing chip prices, further reducing returns on Europe's white elephant megafab. Many resources were wasted due to lacking European coordination in semiconductor investments resulting in the duplication of efforts among Member States. This was aggravated by a poorly balanced approach that saw the failure of a single concentrated megafab investment coupled with many dispersed injections among a myriad of gaps that proved to be spread too thin to enable individual start-ups and initiatives to take off. A structural cause of the failure to sustain the long-term development of Europe's chip sector and its innovation capacity was a lack of continued political support for public semiconductor investment in the years following the adoption of the EU's chip strategy, which was in part due to perceptions of unequal distribution of benefits of related policies.

4. Collapse

In 2030, a six-month Chinese naval and air blockade of Taiwan cuts the world off from Taiwanese chip exports. The blockade is the result of a military stand-off between the US and China following years of build-up tensions in the South China Sea and Taiwan Strait. China attempts to use the world's reliance on Taiwanese semiconductor exports to force a more robust recognition by the West of its sovereignty over Taiwan more in line with its own interpretation of the One China policy. It thereby seeks to cut short gradual international diplomatic creep towards more formal independence of the island as well as growing US military cooperation with Taiwan. The US, meanwhile, is determined to avoid letting China assert control over Taiwan's free democratic society and world-class chip industry. Chinese food aid to Taiwan and foreigners repatriating through air via the mainland are the only exceptions to the blockade. China prepared for the event through semiconductor stockpiling, in addition to greatly expanding its domestic trailing-edge chip production in the past decade. While the EU voiced threats to implement sanctions if China does not lift the blockade, it continues importing products from China, including chips and inputs that it needs to supplement domestic chip production and keep European industries running. US pressure on others to implement severe sanctions on China fails to convince all but a few allies, as Intel's new foundries in Arizona, Ohio and Oregon struggle to fulfil even domestic needs. The global high-end electronics sector is the hardest hit, with many factories coming to a temporary standstill. Taiwan's TSMC is namely still the leading foundry for cutting-edge chip manufacturing which are essential for the production of smartphones, tablets, laptops, desktops, cloud servers and telecommunications equipment. Samsung in South Korea is not able to fill this gap. Severe shortages and delays also occur among automotive and other industries that require less advanced trailing-edge chips, of which Taiwan also produces a large share. Chip reserves in most European sectors, built up in preparation for future disruptions following the shortages one decade ago, proved insufficient to last more than halfway through the blockade. The blockade is eventually lifted after UN-mediated negotiations between China and the US managed to avoid military escalation and roughly re-established the terms of the 1972 Shanghai Communiqué, thus seeing the withdrawal of US military instructors from Taiwan. The 2030 global recession, caused by chip shortages reminiscent of the 2020 pandemic-related semiconductor disruptions but magnified tenfold, once again demonstrated the world economy's severe dependence on Taiwan's cutting-edge chip production. With US-China tensions at an all-time high despite momentary military de-escalation, the risk remains of another significant disruption occurring in the next decade. This dreadful prospect soon spurred a vast wave of government-led semiconductor reshoring and import substitution efforts across the world, dwarfing the various public chip investment strategies of the 2020s.

Questions for policymakers

The following questions for policymakers were formulated on the basis of key factors, identified through the survey and workshop, that participants indicated would help determine the level of success of the EU's semiconductor sector by 2030. In other words, they represent the main drivers that the experts suggested would decide which of the scenarios above should become reality.

On **investment**:

- How do we improve Europe's attractiveness as a semiconductor investment destination in competition with other regions?
- How do we further reinforce existing European semiconductor strengths in equipment manufacturing and design?
- How do we provide a sufficient level of investment in R&D capacity and venture capital for innovative SMEs and start-ups?
- What gaps in EU chip capabilities can we realistically address with the means provided without spreading the resources too thin?
- How do we enhance coordination of semiconductor investments among Member States to avoid the duplication of efforts?
- How do we identify the right semiconductor market trends to invest in?

On **inputs** and **demand**:

- How can we achieve a qualified workforce and sufficient talent pool to further develop Europe's semiconductor sector?
- What can we do to secure our access to raw materials for chip and semiconductor input manufacturing?
- How do we involve and further develop end-user industries to inform policies and build local demand for cutting-edge chips?
- How do we avoid semiconductor investments causing overcapacity in chip production?

On **external** and **environmental factors**:

- What international partnerships could help in reinforcing the EU's chip sector?
- How do we properly protect our IP while remaining open to collaboration with third countries?
- How can we raise our level of preparedness and semiconductor supply security in face of possible future external shocks related to US-China geopolitical tensions, natural disasters, pandemics and other potential disruptions?
- How can we assure that semiconductor sector development will be environmentally sustainable and an enabler for the green transition?

The insights above reflect the perspective of policy experts working on the subject. Future semiconductor-related foresight and consultations could involve a wider range of societal stakeholders including NGOs, media, environmental groups and other civil society to provide a broader public perspective on the EU's chip strategy.

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