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Challenges of a rising Chinese chip design ecosystem

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Abstract

The growing competitiveness of Chinese chip design companies has so far been neglected by policymakers in Europe. Despite the recent US export controls targeting China's semiconductor industry, it is highly likely that Chinese chip design companies will gain global market share in a range of industry sectors in this decade. This presents challenges across the dimensions of national security, supply chain resilience and technological competitiveness for Europe, its end-customer industries and semiconductor companies. Importantly, most of these challenges are not currently addressed by the proposed European Chips Act and will require different and tailored policy responses. Europe must: (a) invest in its own chip design capabilities; (b) strengthen the "strategic indispensability" of its semiconductor companies and technology providers through policy interventions; (c) engage with national and industry actors in discussions on the international structure of the semiconductor value chain and managing conflicting interests, including among the US-allied community; and (d) map the risk profile of increasing reliance on Chinese chip design across different sectors and industry verticals.

Semiconductors are a foundational technology and critical inputs in almost every other industry. Their production can be divided into three distinct steps: chip design, front-end manufacturing (wafer fabrication) and back-end manufacturing (assembly, test and packaging). Since 2020, spurred by global chip shortages, policymakers in Europe, the United States, Japan, South Korea, India and elsewhere have scrutinized their national dependency on foreign semiconductor manufacturing. This has resulted in substantial subsidy packages, such as the proposed European Chips Act, to incentivize the construction of domestic fabrication plants or "fabs".[28] In many ways, policymakers now increasingly care about where chips are manufactured rather than where chips are designed. This has also shaped the

[28] Jan-Peter Kleinhans, Julia Hess and Wiebke Denkena, "Analysis of the EU Chips Act: Challenges of government monitoring of the supply chain", Stiftung Neue Verantwortung, 7 June 2022, <https://www.stiftung-nv.de/en/publication/eca-monitoring>.

way in which policymakers look at China's ambitions and growing importance in the global semiconductor ecosystem. The achievements of China's indigenous semiconductor manufacturing ecosystem, from foundries (such as Semiconductor Manufacturing International Corporation, SMIC) to memory chip manufacturers (such as Yangtze Memory Technologies, YMTC), receive regular media attention but the same is not the case for advances in chip design by Chinese companies, even though this is one of the most notable areas of Chinese progress in recent years.

China's chip design ecosystem has made rapid advances, in some areas such as machine learning accelerators (or "AI chips") even reaching the global cutting-edge. If rigorously enforced, the US export controls instituted in October 2022 will make it highly unlikely that Chinese chip design companies can increase their international competitiveness in high-performance processors, cloud AI accelerators and cutting-edge memory chips. However, most types of semiconductors are not addressed by the new US restrictions.[29] In the areas not targeted by US export controls, Chinese chip design companies will probably continue to strengthen their capabilities and compete internationally. In doing so, they will benefit from China's strength in adjacent industries, such as internet and computing service platforms, consumer electronics and electric vehicles, for which innovation in semiconductors provides a competitive advantage. A globally competitive Chinese chip design ecosystem therefore strengthens the global competitive position of many Chinese companies in other verticals.[30]

This also creates new dependencies and potential challenges for European industries, regarding their long-term technological competitiveness if they come to rely on chips that are "designed in China". The dual-use nature of specific types of chips also means that Chinese chip design capabilities could have defence- and espionage-related implications, which potentially pose national security challenges. These are increasingly of concern to US policymakers in particular, who are already taking unilateral actions in response that directly impact European interests, most notably in the October 2022 export controls.

This chapter provides an overview of the foundation for and long-term potential of China's domestic ecosystem for chip design and examines the impacts on this ecosystem of the October 2022 US export controls. We then analyse the challenges and path-dependencies of China's chip design ecosystem and the implications for Europe along the four dimensions of technology autonomy as outlined in the introduction. We conclude with four policy recommendations on a European response.

29 US Government, US Industry and Security Bureau, "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification", 13 October 2022, <https://www.federalregister.gov/d/2022-21658>.

30 John Lee and Jan-Peter Kleinhans, *Mapping China's Semiconductor Ecosystem in Global Context: Strategic Dimensions and Conclusions*, MERICS and SNV Policy Brief, June 2021, <https://www.stiftung-nv.de/sites/default/files/chinas_semiconductor_ecosystem.pdf>.

Foundations and long-term potential of China's chip design ecosystem

The first factor driving development of China's chip design sector is the concentration and rapid development of end-user industries in China. The semiconductor industry is a supplier market and chips are inputs to countless end-products. This also means that in verticals such as smartphone consumer electronics companies, cloud providers (hyperscalers) and electric vehicle manufacturers, competition increasingly takes place not just at the software level, but also at the hardware level. This virtuous circle of development between verticals that increasingly rely on innovation in chips and the chip design ecosystem creates long-term advantages for China's chip design capabilities.

This is not just about Chinese hyperscalers, such as Alibaba or Tencent, investing in in-house chip design. It is also about a growing number of fabless start-ups, such as Biren Technologies, Black Sesame or Horizon Robotics, designing AI chips and power semiconductors, among many other types of chips, not just to serve domestic companies, but to strengthen their competitiveness on international markets as well. The virtuous circle also means that domestic chip designers can learn and improve through cooperation with domestic and international end-customer industries. This will provide European firms with increasing incentives to partner with Chinese entities. One such example is Volkswagen's new joint venture with the Chinese chip design firm, Horizon Robotics, to develop a System-on-Chip (SoC) for autonomous driving that will be available only in China.[31] Another is the partnership between the Japanese leader in electronics components, Rohm, and Chinese firms like UAES to apply silicon-carbide (SiC) power devices in new energy vehicles.

A second factor supporting the long-term potential of China's chip design sector is China's massive talent pool. Chip design is mainly skill-intensive and thus heavily reliant on highly skilled labour. China has been developing its tertiary education institutions to produce workers for the semiconductor industry, while its chip design sector has benefited from Chinese nationals who have gained work experience with foreign, especially US, firms. However, access to foreign and foreign-trained talent has been put under pressure by China's zero-Covid policy and US government restrictions: the "US persons" provisions in the most recent US export controls impose restrictions on many executives and other important personnel in China's leading semiconductor companies who hold US citizenship or green cards. Chinese industry insiders also see the semiconductor sector as having difficulties competing for university graduates, and the general level of labour force expertise in China as lagging behind that of other countries, although this is more pronounced for electronic design automation (EDA)

[31] Victoria Waldersee, "Volkswagen to take 60% stake in $2 bln tech JV with China's Horizon Robotics", Reuters, 13 October 2022, <https://www.reuters.com/business/autos-transportation/volkswagen-take-60-stake-tech-joint-venture-with-chinas-horizon-robotics-2022-10-13/>.

software and manufacturing than for chip design.[32]

There are objective indicators of the increasing quality of China's skilled workforce in this industry. For the first time, a majority of the accepted submissions to the 2023 International Solid-State Circuits Conference (ISSCC), one of the most prestigious academic semiconductor conferences, for example, were authored by Chinese institutions. Of the 629 submitted research papers, 198 passed screening of which 59 were from China, 42 from the US and 32 from South Korea.[33] So while the "US persons provisions" are certainly a blow to China's chip design ecosystem in the short- to medium-term, China is able to draw on an increasingly competitive academic ecosystem and thus a rich homegrown talent pool. By the Chinese authorities' own judgment, however, effectively linking research with applications for industry will remain a key challenge. China's semiconductor ecosystem has benefited from the practical experience of large numbers of foreign (especially Taiwanese) industry veterans working in Chinese firms and training up local staff. It will take time for large numbers of Chinese personnel to acquire enough applied knowledge from "sitting ten years on the cold bench", to use a local phrase about the necessity for hard-earned experience in the industry.

A third enabling condition for China's chip design sector is state support. In the 1990s, the Chinese authorities were still taking a command-style approach to developing industry champions, but this has evolved over the past two decades into so-called grand steerage, whereby the state channels resources through indirect, market-conforming instruments to "steer" the economy towards broadly defined goals.[34] Among the main instruments of this approach are "government guidance funds", notably the "Big Fund" set up in 2014 for dedicated investment in the integrated circuits industry. Policy support for a given industry also encourages investment by the private sector, including foreign actors. In mid-2022, the Shanghai Stock Exchange established a "STAR Chip Index" for leading firms by market capitalization in China's semiconductor industry.[35]

For many years, Chinese industry policy has made chip design a priority and chip design firms have been notable recipients of investment from the Big Fund. The chip design sector's relatively low barriers to entry and upstream position in the value chain make it an "easy pick" for state officials and fund managers who hope that

[32] Coco Feng, "China's semiconductor self-sufficiency drive needs to strengthen development of talent and skills, education agency executive says", *South China Morning Post*, 5 October 2022, <https://sc.mp/ti4q>.
[33] Michael Herh, "China distinguishing itself at ISSCC 2023", Business Korea, 17 November 2022, <http://www.businesskorea.co.kr/news/articleView.html?idxno=104260>.
[34] Barry Naughton, "Grand Steerage as the New Paradigm for State-Economy Relations", in Frank N. Pieke and Bert Hofman (eds), *CPC Futures: The New Era of Socialism with Chinese Characteristics*, NUS Press, 7 September 2022.
[35] Shanghai Stock Exchange, "Release of SSE STAR Chip Index: Spotlight for Demonstration Effect of Key Technology", 20 May 2022, <http://english.sse.com.cn/news/newsrelease/c/5702887.shtml>.

it will drag along development of downstream value chain steps and end-user industries. Subnational governments in China promote chip design through basic measures such as designating zones for semiconductor-related technology clusters. In Shanghai's Lingang Special Area, for example, design firms such as Cambricon and Horizon Robotics are co-located with firms operating in other steps of the value chain, all of which benefit from import duty exemptions on their inputs.

Impacts of the October 2022 US export controls

A major constraint on China's chip design sector was introduced by the sweeping US export controls instituted in October 2022, which restrict supply of various semiconductor-related technologies to China. These controls are so extensive that they have been described by many analysts as amounting to a strategy of "technological containment" of China. This framing has been reinforced by recent comments on US technology and trade policy by senior officials in the Biden administration.[36]

While these controls do not directly target chip design, their negative effects on the wider Chinese semiconductor sector and the industries that depend on it are likely to dampen demand and investment in Chinese fabless firms, and the in-house design units of Chinese technology majors, at least in the short term. Promulgation of the new controls immediately triggered a stock market fall of around $US 8.6 billion for Chinese firms involved in the semiconductor sector, such as Cambricon and Horizon Robotics.[37] Additional US government controls are expected to follow to restrict outbound investment in China, much of which has been in Chinese chip design firms.

The new controls restrict the involvement of US persons (citizens or permanent residents) in China's semiconductor sector, which will also hamper the development of chip design capability. Many important figures in Chinese EDA software and chip design start-ups are reportedly in this category. The new controls will force such individuals to choose between working in China and their US residence rights, while also making it impossible to attract much of the foreign and possibly Chinese expatriate talent that might otherwise have been ready to work for or with Chinese firms. The US persons provisions are also likely to be a strong deterrent to US semiconductor firms doing business with

[36] The White House, "Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit", 16 September 2022, <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/09/16/remarks-by-national-security-advisor-jake-sullivan-at-the-special-competitive-studies-project-global-emerging-technologies-summit/>; Office of the US Trade Representative, "Remarks by Ambassador Katherine Tai at the Roosevelt Institute's Progressive Industrial Policy Conference", October 2022, <https://ustr.gov/about-us/policy-offices/press-office/speeches-and-remarks/2022/october/remarks-ambassador-katherine-tai-roosevelt-institutes-progressive-industrial-policy-conference>.

[37] Hudson Lockett, "China chip stocks lose $8.6bn in wipeout due to US export controls", *Financial Times*, 10 October 2022, <https://www.ft.com/content/63a408cf-b4cc-4825-a6aa-ad829142e335>.

Chinese entities through shell companies and other clandestine means. This is probably by design, given that one of the "big three" EDA vendors is reportedly under investigation for selling to Huawei and SMIC in breach of older export controls targeted at those individual entities.[38]

Much will depend on enforcement of the new US export controls, which could be revised or expanded in the coming months. If their application is limited to the four areas addressed in the current regulation – high-performance and supercomputing, cloud AI acceleration, advanced semiconductor manufacturing and manufacturing equipment – this is likely to have limited impacts on Chinese chip design companies serving other sectors, such as automotive, mobile chipsets, internet of things (IoT) and industrial applications, at least until the general requirements for computing power in these sectors increase significantly. At the time of writing, however, some new rules have been drafted in terms that potentially allow them to be used to restrict Chinese industry's access to less sophisticated chips. If this is the case, the other sectors mentioned above could be significantly impacted, with negative follow-on effects for Chinese chip design firms. That said, this is not the US government's current intention according to official statements.[39]

Challenges and path-dependencies of China's chip design ecosystem

Notwithstanding the long-term potential of China's chip design ecosystem, it also faces significant challenges. The intensifying US–China technology rivalry essentially means that Chinese chip design companies could be cut off from upstream suppliers (EDA tools and semiconductor intellectual property, IP, vendors) and downstream front-end manufacturing (equipment vendors and fabrication providers) within a matter of months, or potentially even days.

A key challenge for China's chip design ecosystem is its dependence on the US-origin *electronic design automation* tools that are essential for designing semiconductors. Access to EDA tools is essential in order to design chips and the leading EDA tool suppliers, Cadence, Synopsys and Mentor (acquired by Siemens in 2017), are all US-based. While there have been several initial public offerings in China's homegrown EDA ecosystem since 2021, and Chinese EDA start-ups receive a lot of attention from public and private investors, this is still in its infancy.

[38] Ian King and Jenny Leonard, "Synopsys probed on allegations it gave tech to Huawei, SMIC", Bloomberg, 13 April 2022, <https://www.bloomberg.com/news/articles/2022-04-13/synopsys-probed-on-allegations-it-gave-chip-tech-to-huawei-smic>.

[39] Martin Rajser, "A Conversation with Under Secretary of Commerce Alan F. Estevez", Center for a New American Security, 27 October 2022, <https://www.cnas.org/publications/transcript/a-conversation-with-under-secretary-of-commerce-alan-f-estevez>.

ACTOR TYPE	NAME OF KEY ACTOR	DESCRIPTION	KEY TASK	PRIORITY
'Government guidance fund' (state-linked sectoral investment fund)	National Integrated Circuit Industry Investment Fund (Big Fund) 国家集成电路产业投资基金	Supervised by Ministry of Industry and Information Technology (MIIT)	Investment in semiconductor sector in line with policy priorities	
'Leading Small Group' (interagency steering body)	IC Industry Development Leading Small Group (国家集成电路产业发展领导小组)	At time of establishment, vice-chair was Director of MIIT	Policy oversight for the IC sector	
Industry R&D consortium	IC Industry Technical Innovation Strategic Alliance (集成电路产业技术创新战略联盟)	Ministry of Science and Technology is registrar (holds authoritative copy of body's constitution)	Integrated R&D across the IC sector and facilitating collaborative innovation	
Industry representative body	China Semiconductor Industry Association (中国半导体行业协会)	MIIT (supervision and guidance of activities)	Industry assessments and data collection, information exchange, policy implementation, international exchanges, member representation	
Industry consortium	China RISC-V Industry Consortium (中国RISC-V产业联盟)	Led by Verisilicon (publicly listed company)	Development of RISC-V based technology	
Industry R&D consortium	China Open Instruction Ecosystem Alliance (中国开放指令生态)	Chinese Academy of Sciences (Institute of Computing Technology)	Development of RISC-V based technology	
R&D institute	Beijing Open Source Chip Research Institute (北京开源芯片研究院)	Chinese Academy of Sciences (Institute of Computing Technology)	Development of RISC-V based technology, especially Xiangshan HPC open-source processor project	
Company (Foundry provides chip manufacturing services)	Semiconductor Manufacturing International Corporation (SMIC) (中芯国际集成电路制造有限公司 (中芯国际))	Publicly listed company, partially state-owned	China's most advanced fabrication provider	
Company (Equipment maker and systems integrator)	Shanghai Microelectronics Equipment (SMEE) (上海微电子装备(集团)股份有限公司)	State-owned	China's leading producer of photolithography systems	
Company (Memory chip maker)	Yangtze Memory Technology Corporation (YMTC) (长江存储科技有限责任公司)	Holding company-owned	Technologically leading memory chip manufacturer	

Figure 2.1 – An overview of the technical and political actors driving China's 6G development

Like EDA, *semiconductor IP* is another critical input to chip design. Since China is a "fast follower" in the semiconductor ecosystem, having joined the globalized value chain late and in lower value-added steps, there is a relative lack of domestic semiconductor IP. This makes Chinese chip design activities heavily reliant on foreign, especially US, semiconductor IP for core functionalities such as input/output (I/O), memory and compute.

Dependence on foreign providers for *front-end manufacturing (fabrication)* poses another challenge for the growth of China's chip design ecosystem. Most, if not all, globally competitive chips "designed in China" rely on cutting-edge front-end manufacturing in Taiwan. Like the rest of the world, Chinese fabless companies depend on manufacturing by TSMC in Taiwan, specifically for cutting-edge logic chips such as processors, AI accelerators and System-on-Chips. TSMC's dependence on US-origin manufacturing equipment and fab technology means that the US government can always apply the foreign direct product rule to use export controls to block Chinese fabless companies' access to TSMC's fabrication services, leaving them unable to have their leading-edge chip designs manufactured into products.

Implications for Europe

China's chip design ecosystem has a lot of long-term potential even in the light of the latest US restrictions. China already has globally competitive companies in many verticals that directly benefit from innovation in semiconductors, such as hyperscalers (Alibaba, Tencent, Baidu), electric vehicles (BYD, Nio), consumer electronics (Xiaomi), smartphones (OPPO, Vivo, OnePlus) and mobile infrastructure (Huawei, ZTE). A few Chinese firms (most notably Haier) have also become competitive in "smart manufacturing" and "industrial internet" systems, which also benefit from chip design to optimize various functions within these technological ecosystems.[40] The Chinese state encourages the development of all these fields and probably has the resources to further increase effective subsidy levels, especially if this is seen as necessary to compensate for the negative impacts of foreign measures such as US export controls or to support critical import substitution efforts.

Very few, if any, European companies are present in many of these end-customer markets. Consequently, Europe will be increasingly confronted not just with end-products assembled in China, but chips designed in China at the core of these products. The above-mentioned virtuous circle between end-customer industries and chip design capabilities will also enable Chinese chip design companies to enter other verticals, to compete internationally and potentially to supply European

[40] Rebecca Arcesati et al., "China's digital platform economy: Assessing developments towards Industry 4.0", MERICS, 29 May 2020, <https://merics.org/en/report/chinas-digital-platform-economy-assessing-developments-towards-industry-40>.

end-customer industries. Over time, this will create new dependencies among European end-customer industries on chips "designed in China". In the example of Volkswagen's cooperation with Horizon Robotics mentioned above, even if the products of this collaboration serve only the Chinese market, this reinforces Volkswagen's dependence on access to China to remain profitable and a global technological leader.

This prospect of growing European dependence on China's chip design ecosystem, and chips designed in China, will have impacts on Europe's Open Strategic Autonomy. We assessed Open Strategic Autonomy across the four dimensions of supply chain resilience and security of supply, national security, values and sustainability, and technological competitiveness, and offer the following evaluation of each of these dimensions.

Supply chain resilience and security of supply

For the most part, chip design does not depend on physical inputs in the way semiconductor manufacturing does. Thus, generally speaking, an increasingly competitive Chinese chip design ecosystem will have little impact on Europe's security of supply of chips or overall supply chain resilience. If in the long-term European end-customer industries come to increasingly depend on Chinese-origin chips, however, and if the Chinese government implements similar crisis response measures to those currently envisaged in the EU Chips Act (priority-rated orders and export authorizations), Europe's supply of Chinese-origin chips could be disrupted during a future chip shortage due to interventions by the Chinese government.[41] The extent of such impacts would be influenced not only by China's strength in semiconductor design, but also by the share of global semiconductor manufacturing located in China, even if not necessarily owned by Chinese firms.

National security

Increasing dependency on chips designed in China could have negative impacts on national security in EU member states for two main reasons. First, as the US government argues in its justification for its October 2022 export controls, chips used in supercomputers and machine learning have direct military utility in simulating and enhancing preparedness for future armed conflict.[42] The greater national capacity that China has in chip design, the higher the potential strategic advantage to the Chinese military. Second, the threat of hidden hardware backdoors and "kill switches" grows with the increasing complexity of chips.[43] The rise of chiplets and heterogeneous integration as approaches to packaging semiconductors into their end-use form means that the threat of so-called

[41] Jan-Peter Kleinhans and Julia Hess, *Analysis of the EU Chips Act: The Crisis Response Toolbox*, Stiftung Neue Verantwortung, September 2022, <https://www.stiftung-nv.de/sites/default/files/governments_role_in_the_global_semiconductor_value_chain_3_0.pdf>.

[42] US Government, US Industry and Security Bureau (note 299).

[43] Jeff Goldman, "Chip Backdoors: Assessing the Threat", Semiconductor Engineering, 4 August 2022, <https://semiengineering.com/chip-backdoors-assessing-the-threat/>.

hardware hacks must already be considered when implementing a single Chinese chiplet as part of a non-Chinese chip design.[44] These threats are very similar to those that stem from the deployment in Europe of mobile network equipment manufactured by Chinese entities such as Huawei and ZTE.[45] Depending on the type of chip and the use scenario, the trustworthiness of the chip design company and the fab might also be relevant. The increasing presence of Chinese equipment in the rapidly expanding global IoT further amplifies this security risk.[46]

Values and sustainability

A growing dependence on chips from Chinese companies does not pose any challenges to Europe's Open Strategic Autonomy in terms of values. This emerges as an issue once software runs on these systems, such as facial recognition algorithms or other forms of data analysis. At the hardware level, however, there are negligible impacts. Compared to the challenges that stem from the other three dimensions, sustainability issues are also of little concern when assessing Europe's growing dependence on Chinese-origin chips. The Chinese authorities are themselves conscious of the imperative to increase energy efficiency and reduce resource consumption, and these priorities are written into China's various policies on development of the digital industries that depend on semiconductors and chip design.

Technological competitiveness

Next to national security challenges, Europe's long-term technological competitiveness is potentially affected most by the growing Chinese chip design ecosystem. Many products in which European companies have had historically strong positions, such as cars and robotics, increasingly compete at the level of hardware- and software-innovation, as well as optimization of the interactions between the two. These "cyber-physical systems" make up a growing share of economic activity and national infrastructure as a result of the expanding IoT.[47] Even if European companies continue to excel in the traditional electrical and mechanical engineering aspects of these products, Chinese companies might be able to outcompete their European counterparts due to innovation in chip design. Chip design capabilities will reinforce Chinese strengths in other supply chain segments, as is already evident in the electric vehicle sector where Chinese carmakers benefit from Chinese minerals processing and battery making suppliers.

When assessing the impact on Europe's Open Strategic Autonomy in these four dimensions, the effects of the sweeping

[44] Ed Sperling, "Security Risks Widen With Commercial Chiplets", Semiconductor Engineering, 7 July 2022, <https://semiengineering.com/security-risks-widen-with-commercial-chiplets/>.

[45] Jan-Peter Kleinhans, "Whom to trust in a 5G world?", Stiftung Neue Verantwortung, December 2019, <https://www.stiftung-nv.de/sites/default/files/whom_to_trust_in_a_5g_world.pdf>.

[46] Alexi Drew, "Chinese technology in the 'Internet of Things' poses a new threat to the west", *Financial Times*, 10 October 2022, <https://www.ft.com/content/cd81e231-a8d3-4bc0-820a-13f525a76117>.

[47] John Lee, "The Connection of Everything: China and the Internet of Things", MERICS, 24 June 2021, <https://merics.org/en/report/connection-everything-china-and-internet-things>.

US export controls of October 2022 must be taken into account. These restrictions have made the task of balancing the risks and benefits of engaging with China's semiconductor sector and related end-user industries far more difficult. The clear objective of the controls is to completely cut-off China's access to cutting-edge and next-generation computer processors, whether imported or domestically produced. These are the very products that Chinese chip design firms are primarily working on, and this is where their value primarily lies as partners for European firms in end-user industries such as car making, and potentially in more wide-ranging fields such as intelligent manufacturing systems.

DIMENSION OF STRATEGIC AUTONOMY	SHORT DESCRIPTION OF CHALLENGE IN KEYWORDS	RELATIVE IMPORTANCE OF CHALLENGE ON A SCALE OF 1 TO 4	POLICY INSTRUMENTS FOR TACKLING CHALLENGE IN KEYWORDS
Resilience of supply chains	Mitigating risks of interruptions to supply associated with rising dependence on chips designed and manufactured in China	2	Integrated discussions across the US-allied community; mapping and domain-specific risk assessment of dependence on chips of Chinese origin
National security	Constraining China's access to leading-edge military capabilities; guarding against Chinese hardware-enabled espionage & sabotage	3	Integrated discussions across the US-allied community; mapping and domain-specific risk assessment of dependence on chips of Chinese origin
Values and sustainability	Ensuring that the semiconductor industry's development and end-uses are sustainable and in line with European values	1	Coordinated cross-sectoral approach with end-user industries; mapping and domain-specific risk assessment of dependence on chips of Chinese origin
Technological competitiveness	Ensuring that Europe maintains and builds world leading firms that occupy indispensable roles in the global semiconductor supply chain, thereby also providing a foundation for competitiveness in end-user industries	4	EU Chips Act; coordinated cross-sectoral approach with end user industries; focus on sustaining leverage in the global value chain by protecting European firms that are "indispensable" technology providers

Figure 2.2 – Main Chinese semiconductor technology-related risks

Recommendations for European Policymakers

For Europe, these issues are therefore tied to the macro question of Europe's international positioning between the US and China, particularly as the EU itself currently has limited chip design capabilities. In the context of chip design, China's relative position in the global semiconductor industry means that the choice is not between dependence on either the US or China. Instead, it is probably between maintaining access to both US and Chinese technology ecosystems (with a bias towards the former), on the one hand, and the high degree of dependence on US industry that would probably be implied by severing links with Chinese industry, on the other.

The US is pursuing other international cooperative initiatives on semiconductors, notably the so-called Chip 4 Alliance with Taiwan, Japan and South Korea. It is not evident that European interests are being adequately considered in these discussions, and there is already concern in various EU quarters about the implications for European firms' future competitiveness vis-a-vis companies from the US and its East Asian allies. Specifically, it is not clear what consideration is being given to ASML's long-term competitiveness and the consequences for supplier firms such as Trumpf and Zeiss, particularly as the US appears to be dealing with this issue through bilateral discussions with the Netherlands. Nor is it clear that the significant exposure to China of STMicroelectronics, Infineon, NXP and other European firms in the semiconductor sector, or of major semiconductor end-user industries, is being taken into account in discussions on supply chain restructuring.

Conversely, even before accounting for the new US export controls and US political pressure to align against China, integration with China's chip design ecosystem brings significant political risks. China's government recently proved ready to weaponize economic relations against an EU country (Lithuania) over its relations with Taiwan, with consequences also for firms in other EU member states. The intrusive data regulatory regime imposed by the Chinese state means that operating in China will continue to create problems of data security and intellectual property protection for European businesses. The Chinese state is increasingly arming itself with "counter-sanctions"-type instruments in retaliation for foreign measures seen as discriminating against Chinese interests, and Beijing may choose to use these cross-sectorally and disproportionately. Above all, the general advance of Chinese firms' capabilities will increasingly make them effective competitors not only in China, but in third party markets and even the EU itself.

In view of these multifaceted challenges, and of Europe's difficult balancing act amid the intensifying US–Chinese technology rivalry, we make recommendations below on how Europe can mitigate some of the risks of increasing dependence on chips designed in China.

Invest in European chip design through end-customer industries and in technology trends

It is an increasingly severe shortcoming of Europe's semiconductor strategy that, at the time of writing, the Industrial Alliance on Processors and Semiconductor Technologies has still not been launched[48]

[48] European Commission, "Alliance on Processors and Semiconductor technologies", 2022, accessed 5 December 2022, at https://digital-strategy.ec.europa.eu/en/policies/alliance-processors-and-semiconductor-technologies

more than 18 months after its envisaged start date.[49] The alliance and its working groups could provide a suitable forum for European end-customer sectors, such as the automotive, telecommunications, health and manufacturing sectors, to jointly develop technology roadmaps for future chip designs that serve their industries. If Europe wants to strengthen its chip design ecosystem in the long-term, European end-customer industries need to perceive chips as a strategic input and competitive differentiator in their own end-products, in order to justify the necessary investments in in-house chip design units and cooperation with European chip design companies. This is key to European *technological competitiveness* not only in semiconductors, but also in various end-customer industries.

Ensure sustained leverage in other parts on the semiconductor value chain in the long-term

Despite the recent US export controls, China's chip design ecosystem has several systemic advantages compared to Europe's that make it almost certain that European industries will depend more on chips designed in China at the end of this decade than they do today. To strengthen Europe's Open Strategic Autonomy despite growing dependence on China's semiconductor ecosystem, European policymakers must support the preservation and creation of European technology providers that are indispensable to the global semiconductor value chain. The fact that no fab in the world can move beyond 7nm process technology without access to ASML's Extreme Ultra-Violet lithography machines creates geopolitical leverage. This "strategic indispensability" of domestic semiconductor firms to the international ecosystem is a key pillar of Japan's semiconductor strategy.[50]

European semiconductor manufacturing equipment and chemical suppliers have globally competitive, in some cases market-leading, positions in their fields. One aspect of Europe's semiconductor strategy should therefore be to support the continued indispensability of these technology providers not only against Chinese competitors, but also in relation to firms from the US and its East Asian allies. This policy objective should inform assessments of US export controls, even if these only target China, and their potential impacts on European firms.

Such indispensable and market-leading firms are key to Europe's *technological competitiveness* not just in the semiconductor sector, but in many other end-user industries. Their existence also boosts *supply chain resilience* and *national security* by providing points of leverage that Europe can use to counter weaponized interdependence in the semiconductor supply chain.

[49] European Commission, "Updating the 2020 New Industrial Strategy: Building a Stronger Single Market for Europe's recovery", SWD(2021) 350 final, 2021, <https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf>.

[50] Hideki Uno, "Japanese Semiconductor Industrial Policymaking in the Twenty-First Century", CSIS, 19 September 2022, <https://www.csis.org/blogs/perspectives-innovation/japanese-semiconductor-industrial-policymaking-twenty-first-century>.

Engage in EU-level dialogue with other key actors in the semiconductor value chain

At the same time, cooperation with the US and its East Asian allies is important to the sustainable development of a competitive European semiconductor sector. There is no prospect of Europe ever "on-shoring" the entire semiconductor supply chain: *supply chain resilience* must be managed, in so far as is possible, through international cooperation and information exchange. The TSMC-Samsung duopoly on leading edge fabrication is only the most prominent example of why comprehensive onshoring is unrealistic. Europe must build "strategically indispensable" niches in the context of dependence on technology provided by other countries. Within the US allied community, it should be possible to discuss these issues in combined forums where all parties' interests can be addressed. Dependencies on China cannot be handled in the same way for political reasons, but they are also best managed by maximizing communication with Chinese parties on the basis of reciprocity (i.e. not providing information without receiving equivalent information).

Map and assess the domain-specific risks that stem from the use of Chinese-origin chips

While certain market dependencies on Chinese firms are relatively easily identified, the rapid growth of the global IoT and in Chinese industrial capabilities requires extensive and continuing risk assessments differentiated by sector and vertical. Not all Chinese-designed chips and the products they support present an equal risk profile, although common risk factors stem from the Chinese state's political priorities and its intrusive data regulatory regime.

Enabling such comprehensive and detailed risk assessments is another reason why cross-sectoral cooperative forums such as the above-mentioned alliance are important. Without deep visibility of the structure of Europe's digitalized industries and their interdependencies with China – and indeed with other states in the US-allied community – policymakers cannot make informed decisions on risk management for national security, on supporting Europe's future prosperity or on maximizing Europe's Open Strategic Autonomy.

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