Automotive Chips: a European Chokepoint?

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ABSTRACT

The chapter examines the evolving dynamics of the global automotive chip market, highlighting the strategic competition between European chip manufacturers and the burgeoning Chinese electric vehicle (EV) sector. Automotive chips are semiconductors used in vehicles for various functions such as engine control, infotainment systems and driver assistance technologies. They are pivotal to modernising cars, and making them safer, more efficient and more connected. Chinese companies benefit from the country's large EV market by leveraging the massive domestic demand to scale production, reduce costs and accelerate innovation in automotive technology. This local demand provides a robust foundation for Chinese firms to advance automotive chip technology, potentially shifting global market dynamics and supply chain dependencies. Thus, while Europe maintains a stronghold on automotive chip technology due to its longstanding industry dominance, China's rapid advancement in EVs presents both challenges and opportunities for European companies. The study explores the competitive landscape, market trends and the impact of Chinese industrial policies aimed at self-reliance in semiconductor production. It particularly focuses on China's strategic moves to bolster its domestic automotive chip capabilities to support its leading position in the global EV market.

SCORECARD 1 TECHNOLOGY FIELD: AUTOMOTIVE CHIPS

Source of European technology strength	Research and innovation	Intellectual property and patents	Production and commercialisation
	Medium	High	Medium

Type of European technology strength	Technological excellence	Commercialisation advantage	Conditioning of market access	Regulatory, political and normative factors	Sustainability	Research partnerships with third countries
	X					

Degree of European leverage	
	Medium (Low – High)

INTRODUCTION

European companies are still global leaders in the market for automotive chips, which are semiconductors essential to the functioning of cars and other vehicles. The dominant market share and technical leadership of these European firms are based on decades of operation and closely linked to the strong European car making industry, which has provided an end-user for such products. This puts European leaders in this field in a good position to capitalise on the massive expansion in demand and on the technological development pathways for automotive chips being generated by the transition to electric vehicles (EVs) and autonomous driving.

Historically, internal combustion engine vehicles have required only a limited number of chips (semiconductors) – by one estimate, around 160.[1] Today, the growing use

1 Novosense Microelectronics, "Revolutionizing High-Voltage Controller Chips for Electric Vehicles", EETimes, 27 November 2023, accessed 10 April 2024, at https://www.eetimes.com/revolutionizing-high-voltage-controller-chips-for-electric-vehicles/

in new passenger cars of feature-rich infotainment systems, advanced driver-assistance systems (ADAS) and increasingly sophisticated autonomous driving (AD) capabilities is driving a dramatic rise in the chip content of vehicles. Amplifying this trend is the rise of EVs and hybrids, going beyond passenger cars to include vehicles for mass transit and industrial uses such as mining or construction.

Today's highly autonomous EV passenger cars may require 400 or more chips to manage over 100 electronic and electrical components, which are continually evolving subsystems.[2] For example, an EV's powertrain[3] contains ten times more semiconductor content than that of an internal combustion engine car.[4] It is this twin transition of 'intelligentisation' and electrification that is driving chip demand in the automotive industry. While the automotive industry accounted for 8% of the global chip market in 2021, its share could well rise to around 15% by 2030, when the total semiconductor market may be US$ 1 trillion.[5]

China's domestic vehicle industry has emerged as the global leader in EVs and is also at the cutting-edge of intelligentisation. Its rise has been dramatic enough to prompt an EU anti-subsidy investigation into Chinese EV imports, initiated in October 2023.[6] The implications affect not just vehicle original equipment manufacturers (OEMs) such as Volkswagen or Stellantis, but also the supplier ecosystem behind them. Just as a strong automotive industry in the EU has supported European leaders in automotive chips such as Infineon, NXP and STMicroelectronics, the world-leading expansion of China's EV industry is boosting development of Chinese vendors of such chips. This in turn will enhance the competitiveness of Chinese OEMs such as BYD, with potentially major impacts for European firms and national economies.

This paper first provides an overview of the competitive landscape, market dynamics and characteristics of the global automotive chip market. Section 2 elaborates on Chinese policy efforts to strengthen its domestic automotive and semiconductor sector. Section 3 assesses why, how and in which areas China depends on European automotive chip suppliers. The final sections discuss Europe's potential ambitions with regard to China in the area of automotive semiconductors and offers policy recommendations.

THE GLOBAL AUTOMOTIVE CHIP MARKET

As mentioned above, modern cars need many different semiconductors to enable infotainment systems, Advanced Driver Assistance and Autonomous Driving Systems capabilities, electric drivetrains and many other functions. Table 1 provides an overview of the market shares of the largest five chip suppliers by revenue in the total automotive chip market, and in three of its sub-segments by chip type – sensors, automotive microcontrollers and power semiconductors.

Compared to other semiconductor markets, such as memory chips or general-purpose processors, the automotive semiconductor market is not substantially consolidated. The five largest suppliers – Infineon, NXP and STMicroelectronics in Europe, Texas Instruments in the United States and Renesas in Japan – controlled roughly half the global automotive chip market in 2022 (see Table 1). However, several sub-segments of the automotive chip market are substantially more concentrated.

In the *automotive sensors* market, the four largest European chip suppliers controlled more than 50% of sales globally. Sensors (e.g. that measure pressure, temperature, proximity, accelerometers) read the environment and translate this information for use by various systems. The sub-segment of *automotive microcontroller units* (MCUs) is highly concentrated and the leading five suppliers controlled more than 90% of global sales in 2022. MCUs integrate different functions on one chip (processing, memory, input/output peripherals) to control specific operations within a larger functional system. Automotive power *semiconductors* are also a relatively concentrated sub-segment led by Infineon and STMicroelectronics. Power semiconductors in cars manage electrical operations, such as battery

2 Ibid.

3 The powertrain in an EV refers to the set of components that generate power and deliver it to the road, notably the electric motor, battery, and transmission.

4 German Association of the Automotive Industry, "Semiconductor Crisis Requirements for future relevance, competence and resilience for Europe", May 2023, , accessed 10 April 2024, at https://www.vda.de/en/news/publications/publication/semiconductor-crisis

5 McKinsey, "The semiconductor decade: A trillion-dollar industry", 1 April 2022, accessed 10 April 2024, at https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry

6 European Commission, "Notice of initiation of an anti-subsidy proceeding concerning imports of new battery electric vehicles designed for the transport of persons originating in the People's Republic of China", C/2023/160, accessed 10 April 2024, at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202300160

TABLE 1: Global market shares in automotive chips as of 2022

AUTO CHIPS MARKET		SENSORS		MICROCONTROLLERS		POWER	
Infineon	12.4%	Bosch	16.3%	Renesas	27.3%	Infineon	31.9%
NXP	11.6%	Infineon	16.1%	Infineon	23.7%	STMicro	20.3%
STMicro	8.8%	NXP	14.1%	NXP	23.1%	Texas Instr.	11.2%
Texas Instr.	8.3%	Allegro	8.0%	STMicro	8.8%	Onsemi	8.4%
Renesas	7.9%	Melexis	7.8%	Microchip	7.5%	Rohm	5.5%
RoW	51.0%	RoW	37.7%	RoW	9.6%	RoW	22.7%

United States Europe Japan

Notes: Including 3 sub-segments: sensors, microcontrollers and power. Colors indicate headquarter locations of the companies
Source: TechInsights cited by Infineon

charging and control, voltage conversion and control of the electric motors.

The fourth sub-segment of the automotive chip market (not listed in Table 1) is *high performance ADAS/AD* chips. These chips, from suppliers such as Nvidia, Qualcomm and Mobileye, interpret the data from all the different sensors, cameras and radar systems. Since European automotive chip suppliers have almost no presence in this particular sub-segment, this chapter focuses on the other three sub-segments and the automotive chip market more generally.

To better understand the barriers to successfully competing in the different subsegments of the production of automotive chips, and to assess the extent to which China will continue to depend on foreign suppliers of automotive chips, three aspects must be considered.

1. Apart from ADAS/AD chips, automotive semiconductors *do not depend on cutting-edge front-end manufacturing*. For example, modern automotive microcontrollers are mainly manufactured on 20–40 nanometer (nm) fabrication processes. Power semiconductors and sensors are largely not dependent on node shrinkage and are built on older generation 90–180nm processes. According to a forecast by Gartner and ASML, even by 2030, the automotive chip market will largely depend on manufacturing processes at 20nm and above.[7] This, in turn, means that automotive chips are largely unaffected by US export controls (as of April 2024) and China's manufacturing capacity build out in these mature nodes is generally unconstrained.[8]

2. Extensive *safety and reliability certification* constitutes a barrier to entry to the automotive chip market. As an industry, automotive chip suppliers have historically striven for "zero defects".[9] Chip suppliers, foundries and the chip itself must adhere to various safety and reliability requirements in order to sell to automotive companies.[10]

7 ASML, "European Chips Act: ASML Position Paper", 8 February 2022, accessed 10 April 2024, at https://www.asml.com/en/news/press-releases/2022/asml-position-paper-on-eu-chips-act

8 Jan-Peter Kleinhans, Reva Goujon, Julia Hess and Lauren Dudley, "Running on Ice: China's Chipmakers in a Post-October 7 World", Rhodium Group and Stiftung Neue Verantwortung, 4 April 2022, accessed 10 April 2024, at https://rhg.com/research/running-on-ice/

9 Anne Meixner, "The Race to Zero Defects in Auto ICs", in *Semiconductor Engineering*, 7 June 2022, accessed 10 April 2024, at https://semiengineering.com/the-race-to-zero-defects-in-auto-ics/

10 Richard Oshiro, "Fundamentals of AEC-Q100: What "Automotive Qualified" Really Means", Presentation, November 2018, accessed 10 April 2024, at https://media.monolithicpower.com/mps_cms_document/w/e/Webinar_-_Fundamentals_of_AEC-Q100-6Nov2018.pdf

3. The *automotive chip supply chain is quite complex* since chip suppliers sell to distributors, automotive tier 1 suppliers (which provide complete functional systems) and increasingly also directly to automotive OEMs. Standard parts, such as single transistors or simple microcontrollers, are mainly sold through distributors, such as AVNet and Arrow Electronics.[11] Specific chips might be sold by the automotive chip company directly to an automotive tier 1 supplier, such as Denso, Continental or Bosch.[12] Automotive OEMs, especially EV start-ups, are also increasingly sourcing some chips, such as power semiconductors, directly from automotive chip suppliers.[13] Finally, some automotive OEMs, such as China's BYD and Tesla, are developing some chips of their own.

In summary, automotive semiconductors are highly diversified. The broad sub-segments of sensors, microcontrollers, power semiconductors and high-performance ADAS/AD chips all depend on specialised domain expertise and a range of manufacturing technologies. It is no coincidence that the leading automotive manufacturing economies of the past three decades – Europe, Japan and the United States – are also home to the leading automotive chip suppliers, as well as leading automotive tier 1 suppliers. Domain expertise and close cooperation with tier 1 suppliers are critical elements in the competitiveness of automotive chip suppliers.[14]

CHINESE INDUSTRIAL POLICY FOR THE AUTOMOTIVE SECTOR AND AUTOMOTIVE CHIP DEVELOPMENT

The efforts of the Chinese state to develop its domestic automotive industry go back almost to the start of the era of reform and opening up. Partnerships between Chinese and foreign carmakers began in the 1980s. China became the world's largest national car market in 2009, in terms of both sales and production.[15] Industrial policy for the sector targeted electrification from 2001, when a major special project on EV development was initiated under the 863 high-tech R&D programme, and the intelligentisation and networking of vehicles from the mid-2010s. In 2015 and 2017, "Made in China 2025" and a "Medium to Long Term Development Plan for the Car Industry" set relevant quantitative targets over the period until 2025. New energy [electric] vehicles (NEVs) are among the "strategic emerging industries" prioritised in China's current Five-Year Plan for 2021–2025.[16]

Other elements of Chinese state-led industrial policy have supported the transition to vehicles that are electric powered, wirelessly networked and increasingly intelligent. The development of sensors and wireless communications has been pursued since 2009 under the Internet of Things (IoT) rubric, including various trials and implementation of networked and autonomous driving.[17] The sophistication of Chinese manufacturing and new firms' capacity to build capital and scale-up have been boosted by policies on promoting smart manufacturing, the industrial IoT and small and medium-sized enterprises.[18]

11 AVNet, "Automotive and Transportation", accessed 10 April 2024, at https://www.avnet.com/wps/portal/us/solutions/by-market/automotive-and-transportation/

12 NXP, "NXP Honored with Prestigious Automotive Awards", 21 September 2023, accessed 10 April 2024, at https://www.nxp.com/company/about-nxp/nxp-honored-with-prestigious-automotive-awards:NW-NXP-HONORED-WITH-AWARDS

13 Renault, "Renault Group and STMicroelectronics enter strategic cooperation on power electronics", 25 June 2021, accessed 10 April 2024, at https://media.renaultgroup.com/renault-group-and-stmicroelectronics-enter-strategic-cooperation-on-power-electronics/

14 Jan-Peter Kleinhans and Nurzat Baisakova. "The Global Semiconductor Value Chain: A Technology Primer for Policy Makers", Stiftung Neue Verantwortung, October 2020, accessed 10 April 2024, at https://www.stiftung-nv.de/sites/default/files/the_global_semiconductor_value_chain.pdf

15 Yuan Chen, C.-Y., Cynthia Lin Lawell and Yunshi Wang, "The Chinese Automobile Industry and Government Policy", May 2020, accessed 10 April 2024, at https://clinlawell.dyson.cornell.edu/China_auto_mkt_JTRF_paper.pdf

16 Tuyu Zhou, Jorrit Gosens and Frank Jotzo, "China's EV plans: Domestic Market and Policy Developments & Australia-China links in Decarbonisation", Australian National University Policy Brief, 17 April 2023, accessed 10 April 2024, at https://iceds.anu.edu.au/files/Policy%20brief%20-%20EV%202023-04-06_0.pdf

17 John Lee, "The Connection of Everything: China and the Internet of Things", Mercator Institute for China Studies, June 2021, accessed 10 April 2024, at https://merics.org/en/report/connection-everything-china-and-internet-things

18 John Lee, "China and the Industrial Internet of Things", Leiden Asia Center, June 2023, accessed 10 April 2024, at https://leidenasiacentre.nl/china-and-the-industrial-internet-of-things/; and Bown, A., Chimits, F. and Sebastian, G., "China's 'Little Giants' turn up the Heat on Europe's Hidden Champions", Mercator Institute for China Studies, January 2024, accessed 10 April 2024, at https://merics.org/en/comment/chinas-little-giants-turn-heat-europes-hidden-champions

Industrial policies specific to semiconductors and integrated circuits (ICs) have increasingly targeted compound/wide-bandgap semiconductors such as silicon carbide (SiC) and gallium nitride (GaN), which have electrical properties that make them the preferred substrate materials for power chips. For example, Shanghai's 2021–2025 IC industry plan gives high priority to intelligent connected NEVs as an application to be served by integrated development across different steps of the chip supply chain, from chip design to electronic design automation (EDA) tools and chip fabrication (manufacturing).[19]

Technical standardisation is also a focus of coordinated industrial policy. China's Ministry for Industry and Information Technology published a new guidance document on the development of a comprehensive system of standards for automotive chips in December 2023.[20] Chinese actors now play a leading role in international standardisation processes for certain semiconductor categories important to the automotive sector, probably as a direct result of the rapid development of NEVs and other relevant end-user sectors in China. The global semiconductor industry association (SEMI) has chapters

TABLE2: CHINESE AUTOMOTIVE SECTOR-RELATED INVESTMENT FUNDS SET UP IN 2023 (SELECTION)

REGION/COMPANIES	CAPITAL (RMB)	TARGETED FIELDS FOR INVESTMENT (SELECTION FROM GENERAL DESCRIPTION)
Henan/SAIC	4.2 bn [1]	Automotive electronics, semiconductors, extension of the industrial chain
Guangzhou/GAC	10 bn (phase 1)[2]	New energy vehicles (NEVs): energy ecology, intelligent networks, automotive chips
Tianjin/Geely	1 bn (phase 1)[3]	Automotive and new energy, integrated circuits, intelligent connected vehicles (ICVs)
Wuhan (Econ. & Tech Dev. Zone)	50 bn [4]	NEVs, intelligent manufacturing, digital economy,
Chongqing (Liangjiang New Area)	20 bn [5]	NEVs, high-end equipment, aerospace, digital economy,
Hunan (Xiangjiang New Area)	500 mn [6] (phase 1)	ICVs, Artificial intelligence, new materials, intelligent manufacturing

Sources:

1. Sina, “上汽集团：关于子公司参与河南尚颀汇融尚成一号产业基金合伙企业(有限合伙)扩募的公告” [SAIC Group: Announcement on subsidiary's participation in the expansion of Henan Shangqi Huirong Shangcheng No. 1 Industrial Fund Partnership (Limited Partnership)], October 2023, accessed 10 April 2024, at https://vip.stock.finance.sina.com.cn/corp/view/vCB_AllBulletinDetail.php?stockid=600104&id=9556237
2. GAC, “广州汽车集团股份有限公司 关于参与发起设立智能网联新能源汽车产业发展基金的公告” [Announcement by Guangzhou Automobile Group Co., Ltd. on participation in establishing the Intelligent Connected New Energy Vehicle Industry Development Fund)], November 2023, https://img.gac.com.cn/topic/file/2023-11-10/1699612521952-广汽集团关于参与发起设立智能网联新能源汽车产业发展基金的公告.pdf
3. Sina, “吉利集团拟发起汽车领域产业基金，首期10亿元” [Geely Group intends to launch an industry fund in the automotive sector with a first phase of 1 billion yuan], March 2023, accessed 10 April 2024, at https://finance.sina.com.cn/tech/roll/2023-03-06/doc-imyixivu3758544.shtmll
4. Hubei, “武汉经开区设立500亿元车谷产业发展基金“, March 2023, accessed 10 April 2024, at http://www.hubei.gov.cn/hbfb/xsqxw/202303/t20230324_4599024.shtml
5. Chongqing Provincial Government, “两江新区设立200亿高质量发展产业投资基金” [Liangjiang New Area establishes 20 billion high-quality development industry investment fund], March 2023, accessed 10 April 2024, at https://www.cq.gov.cn/zjcq/yshj/zshd/202303/t20230321_11792856.html
6. People's Daily, “首期规模5亿元！湖南湘江红土智能产业基金成立” [First phase of 500 million yuan! Hunan Xiangjiang Hongtu Intelligent Industry Fund established], February 2023, accessed 10 April 2024, at http://hn.people.com.cn/n2/2023/0210/c336521-40296711.html

19 YICAI, “建设全球影响力“东方芯港”！上海临港新片区发布集成电路产业专项规划” [Build a globally influential “Oriental Chip Port”! Shanghai Lingang New Area releases special plan for integrated circuit industry], 3 March 2021, accessed 10 April 2024, at https://www.yicai.com/news/100966145.html

20 Chinese Ministry of Industry and Information Technology, “工业和信息化部办公厅关于印发国家汽车芯片标准体系建设指南的通知” [Notice: Issuing of Guidelines for the Construction of National Automotive Chip Standards System], December 2023, accessed 10 April 2024, at https://www.gov.cn/zhengce/zhengceku/202401/content_6924893.htm

of its standards-setting technical committees in China for compound semiconductor materials, high brightness light emitting diodes (HB-LEDs), used for vehicle interiors among other lighting applications, and information and control (see chapter 12 in this volume).[21]

Chinese governments at different levels and leading Chinese automotive OEMs are directing large sums of capital towards achieving these development goals. An impression of the scale of such funding can be gained from the partial list in Table 2 of relevant investment funds and industry projects established in 2023 alone. These are aimed at driving the development of EVs, automotive chips and underlying technologies, such as those related to SiC wafer production. Not listed in Table 2 is the so-called Big Fund, China's main state-linked fund for chip sector investment, which received significant new capital injections in 2023. To provide one example of Chinese companies' fundraising capacity within this sector, GTA Semiconductor, which manufactures power semiconductors among other products, raised around 13.5 billion renminbi (US$ 1.8 billion) in late 2023 in a funding round that involved national and subnational funds and private investors.[22]

These large sums are unlikely to sit idle, given the existing state of development of China's automotive industry and the ambitious targets being set by subnational governments. The Wuhan-based fund listed in Table 2, for example, is directed at Wuhan's Smart Internet and Electric Vehicle Industrial Park "Car Valley", which in 2023 produced 60,000 NEVs and which according to the Wuhan municipal government's plan should expand this tenfold by the end of 2025.[23]

China now also has a network of research institutes funded and operated by subnational governments, universities and companies, focused on R&D of compound semiconductors so-called third-generation-semiconductors and their applications in power chips. Some of these R&D operations are integrated into large scale production facilities, such as Bronze Technologies' Third Generation Semiconductor Industry Base in Shenzhen, which is reportedly engaged in the entire SiC device supply chain and aiming for an annual output of 2 million SiC devices.[24] Bronze Technologies claims to have a relationship with Infineon, among other foreign industry partners. [25]

SITUATION OF CHINESE INDUSTRY RELATIVE TO POLICY AMBITION

Despite all these efforts and the rapid rise of Chinese EV OEMs, the market share of Chinese firms in automotive chips remains low. Chinese industry figures in public statements in late 2023 estimated that China's import substitution rate for chips across the automotive sector was around 10%.[26] As with many semiconductor industry segments, the dominance of several long-established incumbents makes it difficult for Chinese newcomers to get a foothold in the market. The above-mentioned safety and reliability standards, including certification requirements, present another obstacle to rapid catch-up by new players.

Rather than a significant technical challenge, however, this catch-up is only a matter of time. Some data indicates that for NEVs (as distinct from combustion engine vehicles), import substitution levels for certain chips are rising rapidly. For example, one Chinese market research report of January 2024 estimated that comparing 2022 to 2023, BYD's share of China's power chip market for NEV passenger vehicles increased from approximately 21% to 28%, while Infineon's fell from 22.6% to 9.09%. The same report estimates that Chinese vendors' share of

21 SEMI, "Organisational Chart", September 2023, accessed 10 April 2024, at https://www.semi.org/sites/semi.org/files/2023-09/Standards_OrgChart_2023Sept_v1_0.pdf

22 Reuters, "Chinese auto chipmaker raises over $1.8 billion as Beijing prepares new chip fund", 6 September 2023, accessed 10 April 2024, at https://www.reuters.com/technology/chinese-auto-chipmaker-raises-over-18-billion-beijing-prepares-new-chipfund-2023-09-06/; and Yahoo, "中國力挺半導體產業，積塔半導體完成人民幣135億元融資" [China strongly supports the semiconductor industry, GTA Semiconductor completed RMB 13.5 billion in financing], September 2023, accessed 10 April 2024, at https://ynews.page.link/GDbSM

23 YICAI, "中国车谷：2025年新能源汽车产量力争达到100万辆", December 2023, accessed 10 April 2024, at https://m.yicai.com/news/101942958.html

24 ljiwei, "碳化硅器件年产能将达200万只，青铜剑第三代半导体产业基地预计2023年4月投产" [Annual production capacity of silicon carbide devices will reach 2 million units, Bronze Sword's third-generation semiconductor industry base is expected to be put into production in April 2023], July 2021, accessed 10 April 2024, at https://www.laoyaoba.com/n/785611

25 Bronze Tech, "About Us", accessed 10 April 2024, at https://www.qtjtec.com/en/company

26 China Money Network, "Localization Rate of Automotive Chips in China Doubles, But Is Still Less Than 10%", 10 November 2023, accessed 10 April 2024, at https://www.chinamoneynetwork.com/2023/11/10/localization-rate-of-automotive-chips-in-china-doubles-but-is-still-less-than-10

the main drive power module market for NEVs in China was around 61% by the end of 2023.[27]

Furthermore, as noted above, most automotive chips are manufactured at older ("legacy") fabrication nodes that are generally within the existing capabilities of Chinese industry. Mainland China is currently the location for around 27% of global fabrication capacity at the 20–45 nanometre nodes and some 30% at 50–180 nanometres. In the latter range, mainland China will add more fabrication capacity over the next 3–5 years than the rest of the world combined.[28] Access to these domestic fabs will give Chinese firms designing automotive chips familiarity with the manufacturing process, enabling performance improvements to obtain the certifications needed for their products to be viable for use by automotive OEMs and tier one suppliers.

At present, older chip fabrication nodes are not directly covered by US export controls targeting China, and statements from US officials in February 2024 suggest that US controls will not be extended to these "legacy chips".[29] Thus, for automotive sensors, microcontrollers and power semiconductors, the design and manufacturing capabilities of Chinese chip suppliers are currently not significantly affected or constrained by US export controls.

However, it may still be the case that policy or regulatory steps by foreign governments will have some impact on access by Chinese automotive chip vendors and automotive OEMs to foreign customers and industry partners, which could affect the development of Chinese industry in this area. In addition to the European Union's anti-subsidy investigation concerning Chinese EVs, in late February 2024 US President Joe Biden ordered "an investigation into connected vehicles with technology from countries of concern (expressly including China) and to take action to respond to the risks".[30] In April 2024, a joint statement from a ministerial meeting of the EU-US Trade and Technology Council included a statement that the EU and US "share concerns about non-market economic policies and practices that may lead to distortionary effects or excessive dependencies for mature node ("legacy") semiconductors", and that the two sides "may develop joint or cooperative measures to address distortionary effects on the global supply chain for legacy semiconductors".[31]

On high-performance *ADAS/AD* chips, in the medium to long term, Chinese firms *might potentially be* constrained by a lack of access to leading-edge nodes, due to US, Dutch and Japanese export controls that cut Chinese actors off from the necessary equipment.[32] For now, however, continued Chinese progress on ADAS/AD chips can be expected given China's capacities in artificial intelligence (AI) and software development and that current generation ADAS/AD chips do not necessarily require leading-edge nodes for fabrication. For example, China's Horizon Robotics has reportedly surpassed US AI leader Nvidia to lead the market for one AD chip subsegment, with a market share of over 49%.[33]

On *microcontrollers*, where the incumbent advantage of foreign industry leaders is greater, Chinese products are also starting to meet global industry standards. In early 2023, for example, one of Suzhou Flagchip's MCU series received AEC-Q100 Grade-1 and ISO26262 ASIL-B certifications, while one of Yuntu Semiconductor's MCU series obtained ASIL-B functional safety certification from the

27 Guosen Securities, "能源电子月报" [Energy Electronics Monthly Report], 30 January 2024, accessed 11 April 2024 https://pdf.dfcfw.com/pdf/H3_AP202401311619773549_1.pdf?1706692450000.pdf

28 Kleinhans, J.-P. et al., "Running on Ice: China's Chipmakers in a Post-October 7 World", Rhodium Group and Stiftung Neue Verantwortung, 4 April 2023, accessed 10 April 2024, at https://rhg.com/research/running-on-ice/

29 Sadayasu Senju, "US export curbs on China won't extend to legacy chips: official", Nikkei Asia, 23 February 2024, accessed 10 April 2024, at https://asia.nikkei.com/Politics/International-relations/US-China-tensions/U.S.-export-curbs-on-China-won-t-extend-to-legacy-chips-official

30 US White House, "Statement from President Biden on Addressing National Security Risks to the US Auto Industry", 29 February 2024, accessed 10 April 2024, at https://www.whitehouse.gov/briefing-room/statements-releases/2024/02/29/statement-from-president-biden-on-addressing-national-security-risks-to-the-u-s-auto-industry/

31 European Commission, "Joint Statement EU-US Trade and Technology Council of 4-5 April 2024 in Leuven, Belgium", 5 April 2024, accessed 11 April 2024, at https://ec.europa.eu/commission/presscorner/detail/en/statement_24_1828

32 Goujon, R. and Kleinhans, J.-P., "All In: US Places a Big Bet with October 17 Controls", Rhodium Group, 6 November 2023, accessed 10 April 2024, at https://rhg.com/research/all-in/

33 China Money Network, "Localization Rate of Automotive Chips in China Doubles, But Is Still Less Than 10%", November 2023, accessed 10 April 2024, at https://www.chinamoneynetwork.com/2023/11/10/localization-rate-of-automotive-chips-in-china-doubles-but-is-still-less-than-10 note 32

German Motor Vehicle Inspection Association (Deutsche Kraftfahrzeug-Überwachungs-Verein, DEKRA).[34] While these levels of safety and reliability certification are insufficient for safety-critical ignition or braking systems, they should be perceived as important first steps for new automotive chip suppliers entering the market.

In relation to *automotive power semiconductors,* China is not just heavily investing in the production of SiC wafers and fabs,[35] but also doubling down on filing patents. Chinese patent accumulation has proceeded rapidly since the early 2010s, with a roughly equal distribution between the SiC material and wafer stages, and the power chips that are built on these wafers. This represents a sustained catch-up effort relative to foreign industry leaders. Chinese patent applications overtook those by Japanese companies in 2018 as the latter's technological capabilities matured.[36] These Chinese patent holders represent the breadth of China's R&D ecosystem: appliance manufacturers; the leading companies involved in SiC wafer production, among them BYD, as a vertically integrated automotive OEM; state-owned enterprises; universities; and state-affiliated research institutions.[37]

ASSESSMENT OF DEPENDENCIES

Chinese auto OEMs still appear to be heavily dependent on European automotive chip suppliers for power chips, sensors and MCUs. European vendors, such as Infineon, NXP, STMicroelectronics and Bosch, have leading positions in each of these segments.[38] For example, according to a 2023 article by researchers affiliated with China's Ministry of Industry and Information Technology, Infineon supplied 58.2% of the power semiconductors (specifically IGBTs and MOSFETs) used in China.[39]

China's import substitution challenge is compounded by the rapid growth in its power chip market, which the same researchers estimate will by 2028 have grown by 81% relative to 2020. In May 2023, in response to investor questions, executives from SAIC, one of China's leading state-owned automotive OEMs, said that only around 7 percent of the chips it used were made in China. In June 2023 SAIC announced a semiconductor investment fund of over 6 billion RMB to increase the proportion of its chips made in China to 30% by 2025.[40]

Even the very low proportion of demand in China that is currently met by domestically produced automotive chips – as noted above, still estimated by Chinse industry figures in 2023 to average under 10% – might still include a significant share produced by foreign-invested enterprises, one of which could be the STMicroelectronics-San'an joint venture mentioned below. In 2021 , the president of China's National NEV Technology and Innovation Centre was quoted as saying that apart from chip design, every major step of the automotive chip supply chain was dominated by foreign enterprises. He concluded that China was still at the 'chokepoint' stage in achieving self-reliance in automotive chips, leaving it critically vulnerable to foreign supply chain interdiction.[41]

At the same time, however, European automotive chip vendors (as well as their US and Japanese competitors) depend on Chinese EV OEMs such as BYD, Geely and

34 Ijiwei, "国产重大突破! 云途YTM32B1M系列车规产品获得ISO26262 ASIL–B功能安全产品认证" [A major breakthrough in domestic production! Yuntu YTM32B1M series automotive products have obtained ISO26262 ASIL-B functional safety product certification], 23 April 2023, accessed 10 April 2024, at https://www.laoyaoba.com/n/858190

35 Huang, N., "More than Half of the World's SiC Weafers Might Come from China in 2024", DigiTimes, 23 October 2023, accessed 10 April 2024, at https://www.digitimes.com/news/a20231023PD210/silicon-carbide-china-compound-semiconductor-ic-manufacturing-sic.html

36 Antipolis, S., "Silicon Carbide (SiC) Patents Support the Emergence of a Complete Domestic Supply Chain in China", KnowMade, 20 January 2022, accessed 10 April 2024, at https://www.knowmade.com/technology-news/semiconductor-news/power-electronics-devices-news/silicon-carbide-sic-patents-support-the-emergence-of-a-complete-domestic-supply-chain-in-china/

37 MEMS, "功率碳化硅（SiC）专利全景分析–2022版" [Panoramic analysis of power silicon carbide (SiC) patents-2022 edition], 18 May 2022, accessed 10 April 2024, at https://www.mems.me/mems/patent_investigation_202205/11430.html

38 Infineon, "Fourth Quarter FY 2022 Quarterly Update", November 2022, accessed 10 April 2024, at https://www.infineon.com/dgdl/2022-11-15+Q4+FY22+Investor+Presentation.pdf?fileId=8ac78c8b842ede67018477917fa40020

39 Yu Xinyu, Li Huan and Xu Shiqing, "Research on the Safety Development of the Automotive-grade Chip Industry", in *Electronic Product Reliability and Environmental Testing*, 2022

40 Shihua, T., "SAIC Motor to Set Up USD838 Million Fund for 30% Quota of China-Made Chips", YICAI, 20 June 2023, accessed 10 April 2024, at https://www.yicaiglobal.com/news/20230620-10-saic-motor-to-set-up-usd838-million-fund-for-30-quota-of-china-made-chips

41 "汽车缺芯之痛:激发国产机遇" [The Pain of Automobile Chip Shortage: Stimulating Opportunities for Domestic Production], in Invention and Innovation, vol no.2, pp.12-15, 2021.

Nio as customers. In 2022, China produced almost 60% of EVs worldwide.[42] China is on the way to surpassing Japan as the leading car exporting nation, and over a quarter of exports from China are EVs. BYD has surpassed Tesla as the world's leading EV vendor by units.[43]

The location of so much production capacity in China is likely to promote development of Chinese vendors in the underlying supply chain, as has been the case in other industries such as consumer electronics. By one estimate, on the current trajectory, the Chinese market will represent over 40% of all new EVs sold globally by 2030.[44] Furthermore, when discussing NEVs as distinct from combustion engine vehicles, the market dominance of BYD accelerates China's import substitution, because BYD increasingly uses chips that are designed and manufactured in-house. Other Chinese automotive chip vendors like Silan and StarPower now have shares of China's NEV power chip market that by some estimates exceed that of the leading US vendor OnSemi and are approaching that held by Infineon. Although this is not yet true for SiC MOSFETS, for which China's power chip market remains dominated by STMicroelectronics, this situation could change quickly due to massive expansion in cumulative Chinese production capacity in the SiC chip supply chain, with BYD again playing a leading role.[45]

As discussed above, the "intelligentisation" and electrification of cars is substantially increasing the semiconductor content in modern vehicles. Thus, as long as China is home to the largest EV market, it will continue to be among the most important markets for automotive chip suppliers. This also explains why European automotive chip suppliers as well as automotive OEMs are investing in joint ventures with Chinese semiconductor suppliers, with the aim of maintaining or improving access to China's automotive market.

1. In mid-2023, for example, STMicroelectronics established a joint venture with San'an Optoelectronics for a SiC fab in Chongqing that will use STMicroelectronics's proprietary SiC manufacturing process technology and mainly serve the Chinese automotive industry.[46]

2. Volkswagen, which in 2023 carried out executive retrenchment and major cost cutting at its newly established software division CARIAD, is proceeding with a joint venture with China's leading ADAS/AD chip start-up, Horizon Robotics. It will provide ADAS and AD solutions for Volkswagen's EV models in the China market.[47]

Thus, for European automotive chip vendors, China is more than just a sales market. Like their international competitors, Infineon, NXP and STMicroelectronics all operate joint ventures with Chinese companies and back-end fabs (for assembly, testing and packaging of chips) in China. All three European companies also conduct R&D in China at multiple locations, although NXP closed its advanced power systems R&D operation in China in 2022.

Thus, while China's EV sector heavily depends on chips from European automotive chip vendors, these European companies are also deeply invested in China. This was highlighted by the "Joint declaration of intent on dialogue and cooperation in the area of automated and connected driving" signed between Germany and China during the German Chancellor's visit to China in April 2024, emphasising standards and cross-border data transfers.[48]

42 Hufbauer, G., "China's Electric Vehicle Surge Will Shock Global Markets", East Asia Forum, 21 November 2023, accessed 10 April 2024, at https://eastasiaforum.org/2023/11/21/chinas-electric-vehicle-surge-will-shock-global-markets/

43 Lu, M. and Parker, S., "Global EV Production: BYD Surpasses Tesla", Visual Capitalist, 20 April 2023, accessed 10 April 2024, at https://www.visualcapitalist.com/global-ev-production-byd-surpasses-tesla/ ; and Laura He, "China is 'certain' to have overtaken Japan as the World's Top Auto Exporter in 2023, Industry Group Says", CNN, 10 January 2024, accessed 10 April 2024, at https://edition.cnn.com/2024/01/10/cars/china-cars-overtake-japan-largest-exporter-intl-hnk/index.html

44 Farmer, R. et al., "Capturing Growth in Asia's Emerging EV Ecosystem", McKinsey, June 2022, accessed 10 April 2024, at https://www.mckinsey.com/featured-insights/future-of-asia/capturing-growth-in-asias-emerging-ev-ecosystem

45 Guosen Securities, op. cit.

46 STMicroelectronics. "STMicroelectronics and Sanan Optoelectronics to advance Silicon Carbide ecosystem in China", 7 June 2023, accessed 10 April 2024, at https://newsroom.st.com/media-center/press-item.html/c3186.html

47 Automotive News Europe, "VW's Cariad Software Unit to Cut Costs by 20%, Avoid Forced Layoffs", 14 December 2023, accessed 10 April 2024, at https://europe.autonews.com/automakers/vws-cariad-software-restructuring-avoids-forced-layoffs; and Pandaily, "Horizon Robotics and Volkswagen Group's Software Company CARIAD Announce Establishment of Joint Venture", 8 December 2023, accessed 10 April 2024, at https://pandaily.com/horizon-robotics-and-volkswagen-groups-software-company-cariad-announce-establishment-of-joint-venture/

48 Federal Ministry for Economics and Climate Change and Federal Ministry for Digital and Transport, "Germany and China sign a joint declaration of intent on dialogue and cooperation in the area of automated and connected driving", 16 April 2024, accessed 16 April 2024, at https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2024/04/20240416-deutschland-und-china-automatisiertes-und-vernetztes-fahren.html

Counterbalancing the lack of Chinese access to the US market and potentially to the EU, a significant number of large developing economies are rapidly increasing their use of Chinese EVs. Several Southeast Asian economies in this group are also taking major steps towards integration with the Chinese EV supply chain, including joint R&D and in-country production by Chinese automotive OEMs.[49] Because European automotive chip vendors have significant operations in these countries, increased Chinese involvement in the local supply chain raises potential EU-China interdependencies in this sector.

One example is Infineon's expansion of its manufacturing operation in Malaysia, which will be key to its target to supply 30% of the global SiC device market by 2030.[50] The revenue potential of this expansion is related to around €3 billion in customer purchase commitments and prepayments, around half of which is accounted for by the EV sector. These customers include (alongside non-Chinese companies like Ford) the Chinese automotive OEMs Chery and SAIC, the latter reportedly being investigated under the EU's anti-subsidy investigation into Chinese EVs.[51] The Kulim fab will source SiC wafers and ingots from several international suppliers that include two Chinese companies certified by Infineon as vendors in 2023.[52]

EUROPEAN ASPIRATIONS AND LEVEL OF AMBITION

In this context, *a realistic level of ambition* for European policymakers over the next 10–15 years vis-à-vis China and automotive chips would be mutual dependence at best or self-reliance at worst. The aim should be to *maintain European technological strength* in the face of an unavoidable trend towards Chinese import substitution. This trend is driven by industry and market conditions that are robust over a 10–15-year forward timeframe: the dramatic rise of Chinese automotive OEMs and Chinese industrial strength in the larger automotive/EV supply chain – including inputs and technologies relevant to automotive chips such as those for SiC wafer production. While policymakers are increasingly scrutinising the national security implications of connected vehicles, Europe's automotive industry, including automotive chips, will most likely remain entangled with that of China. Since Chinese EV OEMs seem increasingly to be aiming for a greater degree of autonomy from foreign suppliers, it might be difficult for European automotive chip suppliers to stay indispensable in the medium to long term.

European automotive chip leaders will be hard pressed to maintain market share in China and with Chinese automotive OEMs in their operations abroad (mutual dependence). However, their current technological strengths mean that given the right conditions, they have strong prospects for remaining the preferred vendors for European and other non-Chinese automotive OEMs and component suppliers (self-reliance). These strengths can be highlighted with reference to Infineon, Europe's largest automotive chip supplier by revenue.[53]

- **Research and innovation:** Infineon's R&D spending has averaged above 12% of revenue over the past three years, and in 2023 amounted to around €2 billion.[54] The company is engaged in cutting-edge research on various fronts oriented to commercial applications, such as leading research into GaN chips and AI industrial applications funded through Horizon-Europe in connection with implementation

49 Reuters, "China to set up auto research institute in Thailand as EVs gain traction", 8 December 2023, accessed 10 April 2024, at https://www.reuters.com/business/autos-transportation/china-set-up-auto-research-institute-thailand-evs-gain-traction-2023-12-08/

50 Infineon, "Infineon to build the world's largest 200-millimeter SiC Power Fab in Kulim, Malaysia, leading to total revenue potential of about seven billion euros by the end of the decade", 3 August 2023, accessed 10 April 2024, at https://www.infineon.com/cms/en/about-infineon/press/press-releases/2023/INFXX202308-140.html

51 Ibid.; and Reuters, "Exclusive: EU Investigators to Inspect China's BYD, Geely and SAIC in EV probe, Source", 12 January 2024, accessed 10 April 2024, at https://www.reuters.com/business/autos-transportation/eu-investigators-inspect-chinas-byd-geely-saic-ev-probe-source-2024-01-12/

52 Semiconductor Today, "China's SICC and TanKeBlue to supply silicon carbide wafers and boules to Infineon", 3 May 2023, accessed 10 April 2024, at https://www.semiconductor-today.com/news_items/2023/may/infineon-030523.shtml

53 SemiMedia, "Infineon replaces NXP as the world's number one automotive semiconductor supplier", 9 June 2021, accessed 10 April 2024, at https://www.semimedia.cc/10000.html

54 Infineon, "Company Presentation" November 2023, accessed 10 April 2024, at https://www.infineon.com/dgdl/IFX_FY2023_Q3_web_CN.pdf?fileId=5546d46169067e7f01692847c58d0020 ; and Infineon, "Fourth Quarter FY 2022 Quarterly Update", November 2022, accessed 10 April 2024, at https://www.infineon.com/dgdl/2022-11-15+Q4+FY22+Investor+Presentation.pdf?fileId=8ac78c8b842ede67018477917fa40020

of the European Chips Act.[55] In late 2023, Infineon opened a laboratory to develop and test microelectronic circuits for quantum computers. One of its activities will be to use AI to simulate and predict the aging and failure characteristics of power chips, thereby improving estimation of service life and anomaly detection.[56]

- Intellectual property and patents: As of November 2023, Infineon's patent portfolio included 29,700 patents and patent applications. Around 1850 new patent applications were registered in 2023.[57] It has strengthened this portfolio through strategic acquisitions. For example, following Infineon's acquisition of the Canadian company GaN Systems in 2023, it now holds 350 GaN patent families, strengthening what Infineon in 2022 already claimed was the leading GaN patent portfolio.[58] Other European automotive chip leaders have also accumulated extensive patent portfolios: NXP's in 2023 included 9500 patent families.[59]

- Production & commercialisation: the example of Infineon's Malaysian operations described above shows that if allowed latitude regarding the geographic location of its operations, financing and customers, notwithstanding perceived political risk vis-à-vis China, it can continue to expand production. As with its patent portfolios, strategic acquisitions have reinforced Infineon's competitiveness. Infineon's acquisition of Siltectra and thereby its SiC cutting technology has reportedly allowed Infineon to retain a relatively large amount of useable material during SiC ingot processing, and so reduce input costs for its SiC devices. The acquisition of GaN systems significantly increased Infineon's GaN customer base.[60]

QUALITY OF EUROPEAN TECHNOLOGICAL STRENGTH

In view of the above, some broad judgments can be made about Europe's position vis-à-vis China when it comes to automotive chips, in the context of the wider automotive market and global supply chains.

Ease of circumvention/replication: Among the chips in use in the automotive sector, only the most advanced logic processors are currently beyond the capacity of Chinese industry to produce, due to US export controls and continuing critical gaps in import substitution efforts, notably for photolithography. For most automotive chips, however, Chinese industry not only has the necessary capabilities to develop and manufacture these products, but will increasingly have local advantages vis-à-vis foreign competitors in terms of economies of scale and synergies with Chinese customers and industry partners. China also appears to have achieved a significant level of import substitution upstream in the associated supply chains, for instance in the furnaces and cutting equipment required to make and process SiC ingots for SiC wafer production.[61]

That said, at present China's automotive sector still appears to be extensively dependent on foreign vendors, including the European firms Infineon, NXP, STMicroelecronics and Bosch, at least in three of the four automotive chip categories discussed in this chapter. Substituting these foreign products with domestic alternatives will take many years, and an acceleration of this process forced on China by denial of access to European vendors might require compromises on industry standards that would undermine the competitiveness of Chinese automotive OEMs.

55 Fraunhofer IZM, 'Green, Digital Transformation: Infineon Launches EU Projects for Power Electronics and Artificial Intelligence', 1 June 2023, accessed 10 April 2024, at https://www.izm.fraunhofer.de/en/news_events/tech_news/infineon-launches-eu-projects-for-power-electronics-and-ai.html

56 Swayne, M., "Infineon Opens Laboratory to 'Reinvent the Core Element of the Quantum Computer'", The Quantum Insider, 26 October 2023, accessed 10 April 2024, at https://thequantuminsider.com/2023/10/26/infineon-opens-laboratory-to-reinvent-the-core-element-of-the-quantum-computer/

57 Infineon, "Company Presentation", op. cit.

58 Infineon, 'Infineon completes acquisition of GaN Systems, becoming a leading GaN power house', 24 October 2023, accessed 10 April 2024, at. https://www.infineon.com/cms/en/about-infineon/press/press-releases/2023/INFXX202310-014.html ; and Infineon, 'Fourth Quarter FY 2022 Quarterly Update' accessed 10 April 2024, at https://www.infineon.com/dgdl/2022-11-15+Q4+FY22+Investor+Presentation.pdf?fileId=8ac78c8b842ede67018477917fa40020

59 NXP, 'NXP Recognized as 2023 Top 100 Global Innovator', 17 February 2023, accessed 10 April 2024, at https://www.nxp.com/company/about-nxp/nxp-recognized-as-2023-top-100-global-innovator:NW-NXP-RECOGNIZED-2023-TOP-100-GLOBAL-INNOVATOR

60 Ting-Fang, C., 2023. 'Infineon Upbeat on Next-Gen Power Chips as Broader Market Struggles', Nikkei Asia, 16 March 2023, accessed 10 April 2024, at https://asia.nikkei.com/Business/Tech/Semiconductors/Infineon-upbeat-on-next-gen-power-chips-as-broader-market-struggles

61 Soochow Securities, "碳化硅设备行业深度报告" [Silicon Carbide Equipment Industry In-depth Report], 14 September 2023, accessed 10 April 2024, at https://pdf.dfcfw.com/pdf/H3_AP202310201602189432_1.pdf?1697832796000.pdf

Spillover damage if used as a chokepoint: The dominant position of Chinese firms in many segments of the EV supply chain is well-known. It means that there are many potential avenues for retaliation against European attempts to use automotive chips as a chokepoint. Loss of access to European automotive chip technologies would accelerate the loss of market share in these products by the relevant European firms in China and potentially in other foreign markets too. This would undermine their technological and commercial competitiveness against both Chinese rivals and those from the US, Japan and South Korea, and hence their capacity to support R&D in the wider context of advancing European technological and industrial strength.

DISCUSSING EUROPE'S LEVEL OF AMBITION

All the above implies a *modest level of ambition* for European policies targeting China over automotive chips. European firms throughout this supply chain will suffer from Chinese import substitution, but they will suffer more if forced to cut Chinese ties – whether in China or in the Southeast Asian economies increasingly linked to China – that support their competitiveness in a global market.

Automotive chips are among the few high-tech sectors in which Europe still has firms that lead the market in both technology and scale. This leadership should not be risked by attempts to leverage it against China, given the potential for Chinese retaliation and the bright prospects for Chinese automotive OEMs and automotive chip vendors to continue their advance without access to European products in this field.

European chip vendors are likely to struggle to maintain their current market shares in China in the face of Chinese import substitution and the Chinese government's potential use of its own export controls to exert leverage over supply chain dependencies. One way forward would be to strengthen the competitiveness of European firms throughout the EV supply chain, not only of automotive chip vendors, but also the OEMs that are the end-users of these products, as well as makers of chip and wafer manufacturing equipment.

The following are potential options for policymakers in Europe across four levels of ambition.

- **Level 1: threat prevention.** The ambition for European policymakers would be to ensure that European automotive chips do not contribute to the technological upgrading of the Chinese military. Automotive chips have somewhat indirect military utility since they can also be used to control military vehicles. Beyond that, regarding the potential application of export controls, it would be challenging to objectively characterise the automotive chips in the product categories discussed in this chapter as "dual-use items", although this might be easier with some of the technologies involved in their production. In a wider context, Chinese R&D collaborations and corporate acquisitions that involve relevant fields such as GaN and SiC development should be scrutinised, but with a view to avoiding harming European actors through excessive constraints on participation in beneficial arrangements.
- **Level 2: ability to deny.** If the goal is to utilise China's dependence on European automotive chips to discourage China from going against European security interests, Europe would need to ensure it continues to be easier for China to depend on automotive chips from Europe than to successfully develop domestic alternatives. Loss of access to European automotive chip production would probably harm the competitiveness of Chinese automotive OEMs in the short term, especially in non-Chinese markets, but these effects would be outweighed by damage to European automotive chip vendors and by the boost given to Chinese import substitution in this field. It would also be unlikely to shift the long-term development trajectory of the Chinese automotive sector.
- **Level 3: ability to act.** European options for leveraging automotive chips are constrained by the fact that momentum and leverage across the wider automotive sector and EV supply chain are so heavily in China's favour. Most of the demand for Chinese EVs over the next 10–15 years is likely to be generated within China, while Chinese exports to the developing world are growing strongly. As one reference point, BYD is reportedly confident that even without access to the EU or US markets, it can increase its 2023 exports of 250,000 cars more than tenfold in the coming years. It is hard to see any prospects for making China dependent on Europe for automotive chip technologies when conditions for Chinese advancement in these products can be generated without access to EU markets or supply chains.
- **Level 4: curtailment.** Chinese industry already has the capabilities to develop and produce automotive chips, and Chinese firms have demonstrated the ability to produce competitive products. The complexity of semiconductor fabrication, however, means that a total embargo on China across this field might significantly reduce Chinese industry's

ability to manufacture automotive chips. Nonetheless, China seemingly has everything it needs to become self-reliant in automotive chips so curtailment does not seem feasible at this stage.

POLICY RECOMMENDATIONS

The following recommendations depend on the level of ambition policymakers choose to pursue. The current status quo could be described as threat prevention (level 1). If continued, this would mean minimal intervention in terms of controls on technology, research and investment, focused mainly on prevention of technology transfers with dual-use potential. While this level of ambition entails minimal control aspects, it would still require promotion of Europe's automotive chip ecosystem to support future competitiveness with the aim of achieving indispensability.

If the level of ambition of European policymakers is to ensure a certain ability to deny (level 2) China the ability to act against European security interests, Europe would need to encourage continued entanglement. Thus, following a two-pronged strategy, European automotive chip suppliers would continue to establish technology partnerships with Chinese companies and try to stay ahead of competing Chinese automotive chip suppliers. Such a strategy would encounter difficult challenges since Chinese automotive OEMs are already looking to achieve import substitution.

Even more challenging would be an ambition to ensure Europe a certain ability to act (level 3) vis-à-vis China. It would be unrealistic to think that European automotive chips will continue to be indispensable to Chinese automotive OEMs even in the medium-term. However, technological indispensability would be essential if Europe wanted to protect its ability to act while remaining entangled in China's automotive ecosystem. Europe would need to double down on R&D across the automotive ecosystem, focused on autonomous driving and electrification. Such a strategy would only be possible if European automotive OEMs, tier 1 and chip suppliers all shared the same ambition, which is not necessarily the case. Importantly, this would not just depend on the technological competitiveness of European automotive chip suppliers or whether they continue to play an indispensable role in Chinese EV OEMs. It is very much about the purchasing decisions of Chinese OEMs: if they are willing to sacrifice performance or features for reduced geopolitical risk, there is simply very little Europe could do to keep China from becoming less dependent and more autonomous in automotive chips.

Curtailment (level 4), or essentially forcing China to develop its own automotive chip ecosystem without relying on European technology and research, is neither feasible nor in Europe's best (security) interest. If Europe was ready to cooperate in a total embargo on China's access to foreign inputs for semiconductor fabrication, a short term reduction in China's capacity to manufacture automotive chips might be conceivable. But the political challenges involved with implementing this, which would include attaining not just European consensus but also necessary cooperation from non-European actors, make it an unrealistic objective. Furthermore, the longer term outcome would likely be complete Chinese self-reliance in automotive chips and European companies' loss of access to this market in China.

SCORECARD 2 TECHNOLOGY FIELD: AUTOMOTIVE CHIPS

	Threat prevention	Ability to deny	Ability to act	Curtailment
Feasibility of level of ambition	Medium	Medium	Low	Not feasible
Core policy recommendations	• Prevent technology transfers to China that have dual-use potential • Promote Europe's automotive chip ecosystem to support its future competitiveness	• Encourage China's continued entanglement • European automotive chip suppliers continue to pursue technology partnerships with Chinese companies • At the same time, European automotive chip suppliers take actions to stay ahead of Chinese competitors	• Double down on R&D across the European automotive chip ecosystem, focused on autonomous driving and electrification • Seek to make the European automotive chip ecosystem indispensable to China • Make this the shared goal of actors within the European automotive chip ecosystem (OEMs, tier 1 suppliers and chip vendors)	• None

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