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CHAPTER 3

China's utilisation of natural resources in the semiconductor industry: competition, ambitions and future potential

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Abstract: In the information age, semiconductors and chips have become the centre of attention for leading and aspiring world powers and growing economies. Following its rapid rise as the world's leading manufacturer and exporter, China was expected to excel in the semiconductor industry. While it has certainly shown strong commitment to the manufacture of semiconductors and chips, it is yet to claim its position as their leading producer – a title currently held by what China considers its rebel province, the Republic of China (Taiwan). This chapter examines the stark contrast between China's potential to become the world's number one semiconductor manufacturer and its current reality, where it remains behind smaller economies such as Taiwan, Japan and South Korea. It explores China's vast natural resources vital for the production of semiconductors, including silicon, germanium, palladium, boron and gallium, and offers a critical take on the state of the semiconductor sector in the PRC.

Keywords: China semiconductors, semiconductors industry, semiconductors manufacture, China chips, semiconductors and chips.

1. INTRODUCTION

Semiconductors, by many considered the driving force behind today's technological revolution (Hatcher, 2025), provide substantial economic and political benefits to their manufacturers. Their usage ranges from electronics to transportation, renewable energy, healthcare, military and countless other industries (Hamil, 2023). The significance of semiconductors in politics, the economy and technology cannot be overstated, as they are the key driving force behind current geopolitical shifts, trade tensions and technological competition.

While countries such as the People's Republic of China (PRC), the United States, the Republic of China (ROC, Taiwan), Japan, South Korea and Germany fiercely compete for the title of world's number one semiconductor manufacturer, technological development thrives and political tensions grow (World Population Review, 2025). This chapter seeks to answer why – despite having a vast array of natural resources needed for the manufacture of semiconductors (such as silicon, boron, germanium, gallium and palladium), the PRC fails to claim the place of being a leading global semiconductor producer. The chapter will analyse the Chinese semiconductor industry, its reality, ambitions and potential, as well as claim that what stops China from reaching global leadership is a combination of economic and political factors. It does not, however, aim to portray China as a failed semiconductor manufacturer. This chapter will highlight not only the obstacles and challenges facing the industry, but also the future potential of the PRC and its ambitions towards global semiconductor leadership. In its analysis, this chapter will rely on policy papers, reports, datasets and expert opinions to draw a comprehensive image of the Chinese semiconductor sector. It will approach both economic and political aspects of the industry and compare China's existing production ambitions with its current reality. The chapter will begin with an overview of the significance of semiconductors towards global technology, politics and economy. It will emphasise that having vast natural reserves does not necessarily guarantee one country's success in semiconductor production, highlighting the contrast between potential and reality in the Chinese context. It will then describe the position of the Chinese semiconductor industry from a global perspective, observing several challenges that tame its growth and self-sufficiency.

Lastly, this chapter will combine analysis of the current industry challenges with an examination of the future ambitions and potential of the PRC, assessing its targets and goals while keeping in mind the economic and political shifts affecting them. Through its examination, this chapter will highlight how these two factors influence the Chinese semiconductor industry, leading it to fail in claiming the place of being a leading global semiconductor manufacturer – at least for now.

2. THE SEMICONDUCTOR INDUSTRY INSIDE AND OUTSIDE OF CHINA

Studies and reports show the semiconductor industry as a key for future technological dominance, driving the current economic trends and stabilising national security. Publications such as "The Weak Links in China's Drive for Semiconductors" by the Institut Montaigne describe the crucial role of semiconductors in China's long-term development strategy (Institut Montaigne, 2021). Simultaneously, papers such as "China's Quest for Semiconductor Self-Sufficiency" portray the Chinese semiconductor industry from a global perspective, highlighting the potential implications on other countries such as the United Kingdom and South Korea (Janjeva et al., 2024). No matter the perspective, be it technology, economy or security-focused, the message is clear: semiconductors will play a great role in shaping the future geopolitical landscape. Thus, it is imperative to focus on semiconductors while assessing both the present day and future course of politics, trade and technology.

2.1. SEMICONDUCTORS, THEIR USAGE AND GLOBAL SIGNIFICANCE

In an interview for the StanfordReport (2023), Professor Srabanti Chowdhury has described a semiconductor as an element which can both conduct and block electricity, allowing for a quick switch in the flow of the electrical current (Kubota & Abott, 2023). Widely used in computing, semiconductors serve as a foundation for the development of memory units and microprocessors (Wang & Huang, 2023). They are a key to the production of not only mobile phones and data centres, but also energy systems, electronic vehicles (EVs) and optoelectronics (Wang & Huang, 2023). Professor Chowdhury underlines that:

> "We're always among semiconductors. They are in your computer, your cell phone, your watch, your car, and even in LED lights. Semiconductors are so important because you cannot run your daily life without them. The smarter the world gets, the more the need for semiconductors will increase" (Kubota & Abott, 2023).

Moreover, semiconductors mark a crucial element in the development of military and defence technologies such as satellites, missiles, sensors, actuators and stealth aircrafts (Shivakumar & Wessner, 2023; Gargeyas, 2022). Thus, the application of semiconductors covers numerous industries such as computing, ICT (Information and Communications Technology), military, energy and transportation. Noting their significance across multiple industries, countries such as China, the US and Taiwan shifted their focus to semiconductor production early on, with companies such as the Taiwanese TSMC (Taiwan Semiconductor Manufacturing Company Limited), American Nvidia and the Chinese SMIC (Semiconductor Manufacturing International Corporation) being founded in 1987, 1993 and 2000 accordingly (Tung, 2002; Wang et al., 2024; Li & Feng, 2022).

2.2. China's semiconductor industry

The PRC's industrial planning within the semiconductor sector reaches back to the 1950s, with the "Outline for Science and Technology Development, 1956–1967" marking the country's very first official long-term strategy for technological development (VerWey, 2019). Since 1956, the Chinese semiconductor industry has been steered by the recurring

Five-Year Plans (FYPs), which navigated the PRC's ambitions for technological growth and self-sufficiency (VerWey, 2019). The Chines semiconductor industry has benefited from the top-down, state-led approach. This includes state subsidies, industrial policies and directives towards state-owned enterprises designed specifically to support its growth (VerWey, 2019). As of today, the main beneficent seems to be, along the existing FYPs, the Made in China 2025 policy, which supports the PRC in becoming 70% self-sufficient in the semiconductor industry by 2025 (Janjeva et al., 2024). Furthermore, the state actively assists the industry, with President Xi Jinping underlining its vitality in fulfilling China's strategic goals as early as 2014 (VerWey, 2019). The Big Funds I, II and III have supported domestic semiconductor firms such as SMIC, Huahong Group and CR Micro starting in September 2014 (Janjeva et al., 2024). Over the years, governmental funds have navigated billions of RMB (renminbi) towards the development of semiconductor technology, along the existing frameworks such as lowered taxes and R&D tax credits (Janjeva et al., 2024). The most recent – The Big Fund III from May 2024 – focuses on the development of large manufacturing plants as well as the strive for self-sufficiency and lack of dependence on Western companies, central to this chapter's analysis (VerWey 2019). The Big Fund III also supports the construction of new fabrication plants (fabs) in China, aiming to develop a truly indigenous industry (VerWey, 2019). The top-down approach is crucial for the survival of the Chinese semiconductor industry, with the state being directly or indirectly in control of 43% of its registered capital (Janjeva et al., 2024).

While central to the Chinese Communist Party's (CCP's) directives, semiconductors are not unique to China in their importance to long-term national strategies. Due to their widespread usage and significance in industries such as the military, healthcare and green energy, semiconductors take centre stage in Taiwan, the US, Japan and South Korea (Thadani & Allen, 2023). With its main manufacturing competition based in its economic rival, the US, and in what the PRC considers a rebel province, Taiwan, geopolitical tensions drive the Chinese semiconductor industry almost as much as technological ambitions and economic needs (Hamil, 2023). Hence, Taiwan, South Korea, Japan, the US and China – as the world's top five semiconductor manufacturers – become the leading actors in this chapter's analysis, with particular focus on the geopolitical triangle between China, the US and Taiwan. With the extensive tariffs introduced between February and April 2025 by the administration of the current US President, Donald Trump, towards both China and Taiwan (albeit avoiding the semiconductor industry in Taiwan's case), with the strive for self-sufficiency on China's side, and with Taiwan's reliance on international trade and co-operation, the geopolitical triangle becomes the canvas for the current and future course of development for the semiconductor sector (Chung et al., 2025). Each of the actors has its own reasons for entering the competition. For China, manufacturing semiconductors is central to its ambition of becoming a self-sufficient, global tech superpower, as well as dispersing the Western hegemony and ensuring national security (Goodrich, 2024). Consequently, the US relies on semiconductors for upholding the very same technological dominance and ensuring its position as a global leader, simultaneously supporting the military sector and increasing national security (Semiconductor Industry Association, 2019). Lastly, for Taiwan, semiconductors helped establish the country's importance in trade and technology, thus highlighting its global position, especially in light of its disputed statehood (Reinsch & Whitney, 2025).

3. CHINA'S NATURAL RESOURCES AND THE SEMICONDUCTOR SECTOR

The core analysis of this chapter focuses on the contrast between China's potential and its reality in semiconductor manufacture, taking into account its near-dominance in the export of natural resources needed for producing semiconductors. Through analysing the key materials used during the semiconductor manufacturing process and China's position in their respective global markets, this chapter will underline the PRC's advantageous position in the semiconductor industry. Then, by contrasting China's abundant natural resources with its economic and geopolitical challenges, it will aim to explain why China seems to lack definite dominance in the aforementioned sector.

3.1. GERMANIUM AND GALLIUM

Baskaran and Schwartz (2024) identify four key minerals essential to the process – germanium, gallium, silicon and palladium. Germanium, a scarce material sourced from zinc, is crucial to the manufacture of high-speed transistors and wafers, and is predominantly found in China, with about 60% of world export coming from the PRC (Baskaran & Schwartz, 2024). In 2023, the total value of China's exports of germanium oxides and zirconium dioxides reached $124,990.09, with 15,401,300 kg of material exported (World Bank, 2023b). China's leading competition in the semiconductor industry – Japan and the United States – follow right behind with a total export value of $48,848.53 and $45,127.76 respectively (World Bank, 2023b). In order to be used in semiconductor production, germanium needs to be refined – and with the majority of its refinement frameworks established in the PRC, the country gains significant advantage not only with the export of the mineral, but, most importantly, in its utilisation in the semiconductor sector (Baskaran & Schwartz, 2024). Similar robustness can be observed in the case of gallium, with China having exported $141,167.37 total value of the mineral in 2023 (combined with the export of hafnium, indium, niobium, rhenium and thall), right behind Brazil, which exported $210,669.49 (World Bank, 2023a). Gallium's critical role in semiconductor production can be highlighted by its usage in groundbreaking technological achievements, such as the construction of the world's largest N-polar gallium nitride wafer, considered a true maverick in the semiconductor sector, allowing for lower production costs and better adaptation of semiconductors in electric vehicles (EVs) and satellites (Zhang, 2025). Both germanium and gallium are byproducts of other materials, called "minor metals", and with their significance to the semiconductor sector and their mass-scale export by China, they provide substantial benefit to the PRC (Liang & Marsh, 2023).

The data presented above, though relatively recent, can lack a crucial component in the 2025 analysis – the trade tensions between China and the US. It is vital to note that in December 2024, following the US's further technology restrictions imposed on the PRC, China responded with an export licensing system on numerous natural resources, including germanium and gallium, to the US, thus affecting the state of global germanium and gallium markets and contributing to the shielding of Chinese natural resource exports from one of its main technological competitors (S&P Global, 2025).

3.2. SILICON AND PALLADIUM

The next two key materials described by Baskaran and Schwartz are silicon and palladium, of which China has exported a total value of $124,990.09 and $26,970.65 in 2023 (World Bank, 2023d; 2023c). That year, China was the world's leading silicon exporter, having sold 563,729,000 kg of the material, mostly to Vietnam, Japan, South Korea, Indonesia, Thailand and India – all of which are its key competitors in the semiconductor industry (World Bank, 2023d; 2023c). Being the most popular material used in the production of chip wafers (used for the production of microchips), silicon gives China an enormous advantage in the field (Baskaran & Schwartz, 2024). Goswami (2023) describes it as "the most economically important mineral for semiconductor manufacturing", and though widely spread, only the refined, pure silicon can be used for chip production, further exemplifying China's dominant hand as its world's number one producer, accounting for around 70% of the global market. As for palladium, the only mineral that China is not in the world's top two exporters, the PRC has exported a total value of

$26,970.65, way behind its competitors such as the US, South Korea and Japan (World Bank, 2023c). Palladium is used to ensure the longevity of semiconductors, with its high durability marking a key factor in the production and maintenance of chips (Baskaran & Schwartz, 2024). Thus, the mineral is crucial not only for manufacturing semiconductors but also for ensuring their long-term use. In 2023, China imported approximately $1,220,938.78 of palladium, unwrought or in powder form (World Bank, 2023c). Its main exporters to China are Russia, the US, Japan, South Korea and Germany (World Bank, 2023c). From the perspective of natural resources, palladium seems to be the only challenge among the four key elements needed for semiconductor production, as outlined by Baskaran and Schwartz (2024). In all except one of the four key resources, China upholds its position as at least the second global manufacturer, strengthening its position within the semiconductor manufacturing industry.

As such, focusing solely on natural resources and minerals, China has all the means to become a leading global semiconductor manufacturer. This chapter, however, wishes to outline several challenges halting China's development in the semiconductor sector, thus pushing it behind its competitors such as the US, Japan and South Korea.

3.3. Industrial dominance and lack thereof

Despite China's upper hand in the global export of minerals crucial for producing semiconductors, the country fails to claim the title of a world leader within this sector. In fact, China holds the world's third largest number of semiconductor manufacturing plants, and the world's fifth largest production of semiconductors (World Population Review, 2025). Although still on the top five podium, these numbers contrast with the existing aspirations of the PRC. This chapter wishes to identify two major intertwined factors behind this issue: economic dependence and geopolitical pressure. The production of semiconductors is a lengthy process which relies strongly on the value chain, described by the Institut

Montaigne as "a chain of trust" (Institut Montaigne, 2021). The Institut outlines the three main stages of the production chain:

- Design – mostly within the fabless model, without physical manufacturing infrastructure and mostly dominated by the US;
- Manufacturing – mostly in the control of the Taiwanese TSMC (Taiwan Semiconductor Manufacturing Company Limited) and UMC (United Microelectronics Corporation), Chinese SMIC (Semiconductor Manufacturing International Corporation) and American Global Foundries;
- Assembly, testing and packaging – divided mostly between Chinese and Taiwanese firms (Institut Montaigne, 2021).

The equipment and infrastructure used throughout the production chain – from design and manufacture to assembly, testing and packaging – come from various destinations, private firms or state-subsidised actors. Institut Montaigne highlights that of the leading semiconductor manufacturers, "only a few industry giants integrate all three phases" of the production chain (Institut Montaigne, 2021, p. 10). The dominant actors within the market (by revenue) are Intel, Samsung, SK Hynix and Micron Technology – all American or South Korean firms (Institut Montaigne, 2021). For years, China has relied on international interdependence in the microelectronic sector, with its main competitors subsequently relying on the PRC throughout the manufacturing process. When it comes to the equipment and software, Institut Montaigne notes that "China's manufacturing capacity does not meet the need of its foundries", underlying the PRC's dependence on global supply chains (Institut Montaigne, 2021, p. 27).

The Institut Montaigne highlights China's reliance on foreign intellectual property (IP), foreign equipment and technologies in all stages of the semiconductor production process (Institut Montaigne, 2021). The road to self-sufficiency is prolonged and challenging, but, perhaps exactly because of that deeply-rooted interdependence, the PRC's ambitions seem to stay right on course. It is essential to mention that a big portion of the equipment and IP needed for the development of semiconductor technology comes from China's main competition – the US and Taiwan (Institut Montaigne, 2021). Amidst an upcoming trade war, the US has pressured Taiwan to limit its economic and technological cooperation with China, which left the ROC – operating under a direct threat of a Chinese invasion – to cease accepting new orders from Chinese firms such as Huawei (Institut Montaigne, 2021). The political tensions between China, the US and Taiwan fuel geopolitical tensions between the countries and influence global economic trends, especially in the field of semiconductors (Silver et al., 2023). The US has imposed licensing against Chinese semiconductors, most notably throughout the Biden and the Trump administrations (Institut Montaigne, 2021; Caloca, 2025). Taiwan have also been affected by US licensing, with 32% tariff on the island's exports imposed in April 2025, although one notably excluding semiconductors (Chang & Huang, 2025).

This geopolitical triangle between China, the US and Taiwan affects the Chinese semiconductor industry by – perhaps ironically – pushing it further towards isolationism, thus *de facto* forcing the PRC to rapidly implement its 70% self-reliance strategy. The US, aiming to strengthen its military and technological dominance, and Taiwan, seeking a security guarantee under the threat of a Chinese invasion, create a tight lock, simultaneously challenging the Chinese semiconductor industry and fuelling its strive for self-reliance.

4. LOOKING BEYOND NATURAL RESOURCES

The paradox of China's ongoing isolation within the semiconductor industry is one of the most important points in this chapter's discussion, mostly due to its unpredictable nature. The state of the global semiconductor supply and production chains changes rapidly. However, as of now, the key dynamics appear to be centred around the intersection of politics and economics, with rising tensions, new tariffs and licenses affecting China's global position in the semiconductor industry. It remains to be seen if President Trump's engagement in the trade war will in fact benefit the American tech industry, contributing to its self-reliance – an ambition notably similar to the objective outlined by the CCP for their national semiconductor sector (Yeh, 2025).

The challenges facing the Chinese industry certainly affect its lack of global leadership in semiconductor manufacturing. But, possibly, can the same strive for separating China from the global supply chain force the PRC to become more self-reliant? It is indeed difficult to provide an answer to this discussion with full certainty. Taking into account the unpredictability of the Trump administration, the rapidly changing geopolitical and economic environment across the globe and the rapid technological development, the implications cannot be calculated precisely. After all, China has already exceeded expectations in the semiconductor industry. The policy paper prepared by the Institut Montaigne, which served as a core source for this chapter's analysis, states that China will not be able to claim technological supremacy within the semiconductor sector until it can develop at least a 7-nanometer manufacturing process which it calls the "The 7-nanometer threshold", which at the time was only found in Taiwan (Institut Montaigne, 2021, p. 15). The smaller the manufacturing process, the better the overall production capacity: for example, 5-nanometer technology allows "15 more times the number of transistors than 30 nm technology" (Institut Montaigne, 2021, p. 15). However, since then, China has not only fully developed a 7-nanometer but also claimed to have developed a 5-nanometer chip, and although still a generation behind TSMC, it is investing broadly in the development of semiconductor technology, offering large sums of subsidies and investments to firms such as SMIC (Staff, 2024).

China's commitment to research and development of new technologies cannot be underestimated while analysing its position on the global semiconductor market. China is not the world's leading semiconductor manufacturer – geopolitical and economic factors have halted its aspirations to become one. Yet, perhaps, it is precisely these factors that will in turn push the PRC towards more rapid development of indigenous technology and towards achieving the CCP's ambition of self-reliance?

5. CONCLUSION

This chapter depicted semiconductors as one of the most important technological and economic factors, fuelling the development of the electronics, health, military and many other sectors. It has been established that the CCP views semiconductors as pivotal in China's long-term development strategy, aiming for the country to become at least 70% self-reliant when producing semiconductors by 2025 (Janjeva et al., 2024). The CPP's attention to the semiconductor sector cannot be understated, marking one of the top priorities of the People's Republic in its FYPs (Janjeva et al., 2024).

Yet, despite its significant advantage with minerals needed for semiconductor production such as germanium, gallium, palladium, silicon and boron, China fails to claim the title of the world's leading semiconductor manufacturer, remaining behind its main competition – the US, Taiwan, Japan and South Korea (World Bank, 2025a; 2025b; 2025c; 2025d; 2025e; World Population Review, 2025). This chapter has highlighted the PRC's economic dependence on the global production chain, showing how the complexity of the semiconductor manufacturing process results in the PRC's dependence on its strategic rivals, thus halting its self-reliance. This economic interdependence is later affected by geopolitical tensions, with new licences limiting China's trade capabilities. Hence, it has established that a combination of economic and political factors challenge China's ambition to become the world's leading semiconductor manufacturer. In a world of limited resources, an upper hand in vital minerals offers an outstanding advantage in the global market. However, the semiconductor industry does not operate in a vacuum. In the case of China, a significant advantage in natural resources is not enough to gain definite dominance over other economies in semiconductor production.

Other forces, such as political tensions and economic trends, influence the course of technological development, thus highlighting the interplay between natural resources and the reality of global power shifts.

This chapter ended its discussion by questioning whether the newly imposed tariffs and the ongoing isolation of China from the global semiconductor market may in fact contribute to its smoother adaptation of the 70% self-reliance objective. It remains uncertain whether the PRC will reach its 70% self-reliance threshold, and whether its deepening separation from the global supply chain will push it away from interdependence.

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