SECURITY AND SUPREMACY: AN EXAMINATION OF THE US-CHINA TECHNOLOGICAL RIVALRY IN THE SEMICONDUCTOR INDUSTRY

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ABSTRACT

The US-China competition in the semiconductor industry represents a strategic rivalry that stops short of direct conflict. This competition is particularly intense because semiconductors are a critical strategic commodity, underpinning advanced commercial and military technologies that enhance national power. Due to the oligopolistic nature of the semiconductor supply chain, both the US and China aspire to dominate this sector while diminishing the other's influence, leading to heightened competition within the industry. Drawing on data from the World Intellectual Property Organisation (WIPO) and the World Trade Organisation (WTO) spanning 2010 to 2022, this article examines the US-China semiconductor rivalry through the lenses of innovation leadership and supply chain security. In terms of innovation, the US holds a clear advantage over China, although China is making gradual progress. While the semiconductor export market shares of the US and China were comparable until 2013, China overtook the US in 2014, with the gap continuing to widen. However, this growth has been accompanied by a significant trade deficit in semiconductors, underscoring China's heavy dependence on foreign sources to sustain its manufacturing sector. China's pursuit of global technological leadership and its alleged unfair trade practices pose a challenge to US national interests, further intensifying the competition. In response, both countries have implemented various industrial and foreign policies aimed at strengthening their respective positions in the semiconductor supply chain while undermining each other's advantages.

Keywords: Technological Security, Technological Leadership, Semiconductor, US-China Technology Competition.

INTRODUCTION

Few anticipated that a trade war could evolve into a technological competition. Since Donald Trump assumed the US presidency in 2017, the United States (US) has engaged in a technology war with China, ostensibly aimed at addressing trade imbalances and concerns about intellectual property theft (Liu et al., 2022). This rivalry intensified during the COVID-19 pandemic when the US encountered severe vulnerabilities in its technological supply chain, particularly due to chip shortages that forced factory closures. This crisis served as a wake-up call for the US and other major economies, highlighting the fragility of the global semiconductor supply chain (Bauer et al., 2020).

When Joe Biden succeeded Trump as the 46th President, his administration escalated the technological competition with China. This was marked by the introduction of the CHIPS and Science Act, designed to safeguard US technological

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leadership and constrain China's technological advancement, further intensifying the rivalry. A significant aspect of this competition is the rise of China's technological power. In 2015, President Xi Jinping unveiled the Made in China 2025 (MIC 2025) policy, which aimed to establish China as a global leader in advanced technologies and bolster its international economic competitiveness (Ding & Dafoe, 2021; Wübbeke et al., 2016, p. 11). The policy seeks to achieve technological self-sufficiency while increasing other countries' dependence on Chinese products (Wübbeke et al., 2016). The MIC 2025 initiative has enhanced China's technological position and eroded the US' technological dominance, as many nations, including European states, have relied on Chinese products to develop their telecommunications infrastructure. Moreover, China's technological progress has facilitated the modernisation of the People's Liberation Army (PLA), incorporating artificial intelligence into its warfighting capabilities and expanding anti-access/area denial (A2/AD) strategies, which pose significant challenges to US military operations in the Indo-Pacific region (Jenkins, 2023).

The US-China technological competition is particularly pronounced in the semiconductor industry. As noted by the Semiconductor Industry Association (2023), semiconductors are the foundation of modern technologies, including quantum computing, artificial intelligence, and telecommunications. The semiconductor production process is highly complex, with various states controlling different stages of the supply chain; no single nation has a fully autonomous manufacturing capacity. This interdependence exposes both the US and China to distinct vulnerabilities, as each relies on other countries for specific segments of the semiconductor supply chain (Allison et al., 2021, p. 21; Mark & Roberts, 2023; Thadani & Allen, 2023). Recognising these weaknesses, both nations have prioritised securing their semiconductor supply chains to reinforce their economies and militaries. However, the competition has extended beyond supply chain security, with both countries vying for dominance in the global semiconductor industry.

Against the backdrop of the US-China strategic rivalry in the semiconductor sector, this article examines the role of semiconductors in the technological competition between the two nations and the factors driving the US into this contest. Specifically, it addresses the question: What motivates the US and China to engage in strategic competition within the semiconductor industry? The analysis is framed around two key arguments. First, the vulnerabilities within the semiconductor supply chain have compelled both the US and China to enhance their supply chain security, inadvertently fostering competition over market share. Second, the strategic importance of semiconductors, particularly their role in underpinning modern technologies, has driven both nations to vie for dominance in the industry. As a result, the US and China are locked in a competition for both security and leadership in the semiconductor sector.

This study adopts a mixed-method approach to analyse the US-China semiconductor competition. Firstly, it investigates trends in semiconductor innovation using data from the World Intellectual Property Organization (WIPO). Secondly, it examines trends in the import and export of semiconductors by the US and China, utilising data from the World Trade Organization (WTO), to assess the trade dynamics within the industry. The timeline selected spans 2010 to 2022, enabling an exploration of changes following Xi Jinping's ascent to the presidency of the People's Republic of China and the implications of the COVID-19 pandemic, which began in late 2019. The choice of 2022 reflects the latest available comprehensive data from WIPO and WTO. While these statistics may have limitations, they provide a foundational perspective for understanding the underlying causes of the US-China semiconductor rivalry.

The next section reviews existing literature on technology and great power competition, followed by an explanation of the research framework. The subsequent section explores the role of semiconductors as a strategic technology and examines trends in the US and Chinese semiconductor industries using WIPO and WTO data. This is followed by an analysis of the policies implemented by the US and China in their competition, alongside an exploration of the underlying rationale for their rivalry. The article concludes by summarising the findings and offering recommendations for future research.

LITERATURE REVIEW

A general definition of technology is the application of scientific knowledge to practical uses in human life and the transformation of the environment (Britannica, 2022). As a component of national power, technology encompasses a country's capacity to develop sophisticated "critical technologies" and its ability to foster new inventions (Tellis et al., 2000, pp. 53–54). One defining characteristic of technology is its disruptive potential, which can render previous innovations obsolete (Diesen, 2021). State actors are motivated to enhance their technological capabilities as this amplifies other elements of national power.

The strategic importance of technological innovation shapes its role in great power competition. Drezner (2019b) categorised technological innovations using a 2x2 matrix defined by public or private sector dominance and high or low fixed costs, resulting in four types: prestige tech, strategic tech, public tech, and general-purpose tech (p. 292). This framework aids in understanding the pace of technological diffusion and its implications for international politics. Similarly, Ding and Dafoe (2021) evaluated the strategic significance of different assets based on their importance, externality, and degree of nationalisation (p. 184). They argued that externalities are paramount in determining strategic value, assessed through cumulative, infrastructure, and dependency logics (p. 184). Cumulative logic emphasises barriers to entry, first-mover advantages, and firm size; infrastructure logic considers the ease with which technologies can enhance national economic or military systems; and dependency logic assesses the substitutability of a given technology (Ding & Dafoe, 2021, p. 185).

Technological advancement is also crucial for economic development. Leading sector theories posit that states dominating frontier technologies gain first-mover advantages over competitors. Growth in these leading sectors propels a state's economy, influences global economic trends, and reshapes the international division of labour (Drezner, 2019b, pp. 286–303; Hahn, 2020, pp. 2–3; Reuveny & Thompson, 2001, pp. 707–708; Tellis et al., 2000, pp. 20–21; Weiss, 2005; Wu, 2020, pp. 103–108).

Furthermore, technology strengthens a state's military power and transforms the nature of warfare. States that effectively translate economic and technological advancements into military strength gain significant advantages over rivals (Blagden, 2021; Caverley, 2007; Geis & Hailes, 2016; Riikonen, 2019; Talmadge, 2019).

Governments incentivise public sector efforts to develop critical technologies for military modernisation (Miller, 2022; Schreiber, 2022). Great powers must maintain technological, economic, and military superiority, as military power remains the ultimate arbiter in great power conflicts (Knorr, 1975; Mearsheimer, 2003; Tellis, 2009, pp. 41–42). Advanced technologies such as biotechnology, nanotechnology, and directed energy systems can alter deterrence dynamics by increasing uncertainty in state and non-state actors' intentions (Geis & Hailes, 2016). Artificial intelligence has garnered significant attention due to its dual-use potential and capacity to integrate decision-making processes (Horowitz, 2018; Riikonen, 2019; Schmidt, 2022). Cyberwarfare similarly remains a focal point, given its ability to disrupt national infrastructure without kinetic force (Akdag, 2018). Consequently, state actors must continually adapt to frontier technologies to secure national interests and maintain military dominance (Mahnken et al., 2023).

Technological leadership also allows states to reshape the international order, particularly by assuming leadership in the global economic system. Extending long-cycle and leading sector theories, states that dominate frontier technologies can assert global leadership (Boswell, 1995; Boswell & Sweat, 1991; Modelski & Thompson, 1996). Conversely, a great power or hegemon risks losing global influence if it relinquishes its monopoly over leading technologies (Drezner, 2001, p. 24; Reuveny & Thompson, 2001, p. 709). Drezner further argues that the nature of technology can determine whether states compete or cooperate in its proliferation (Drezner, 2019b, p. 300). Due to its disruptive nature, technological innovation can reshape the international order and balance of power, often precipitating great power competition.

Most studies examining technology and great power competition focus on security. For example, Schreiber (2022) explored Russia's competition with the US in space technology; Wu (2020) analysed US-China technological rivalry during the Trump administration; and Schmidt (2022) investigated great power competition in artificial intelligence. Additionally, many studies address military technology competition through the lens of balance-of-power theory, reflecting a neorealist perspective. However, alternative theoretical approaches have also been employed. For instance, Akdag (2018) utilised power transition theory to explain the absence of cyber conflict between the US and China, despite China's dissatisfaction with its cyber status. Similarly, Rovner and Moore (2017) applied hegemonic stability theory to assess whether the cyber domain requires US leadership.

In summary, technology enhances a state's economic and military foundations, driving economic growth and transforming the nature of security and warfare. States with advanced technological capabilities can assert global economic leadership and influence international technical standards. Consequently, state actors actively pursue and seek to dominate frontier technologies to outpace rivals, safeguard national security, and achieve hegemonic ambitions.

THE US-CHINA SEMICONDUCTOR COMPETITION

While semiconductors may not be the sole determinant of national power, their critical importance is undeniable, positioning them at the heart of the US-China strategic rivalry. This section begins by examining the role of semiconductors as both a strategic technology and a strategic asset, shedding light on why they have become a focal point of contention. It then analyses trends in the semiconductor industries of the US and China over the period from 2010 to 2022.

Semiconductor as a Strategic Technology

The semiconductor supply chain is exceptionally complex and highly diversified. According to the Semiconductor Industry Association (2023), it comprises three primary segments: design, front-end manufacturing (wafer fabrication), and back-end manufacturing (assembly and testing). The design phase includes electronic design automation and intellectual property licensing, while manufacturing requires advanced chipmaking equipment and specialised materials. ASML, a leading chipmaking equipment firm, categorises semiconductors into logic, memory, application-specific integrated circuits (ASICs), and system-on-a-chip (SoCs). Logic and memory chips are produced during front-end fabrication before being integrated into ASICs or SoCs during back-end processes.

The geographical distribution of key players in the semiconductor industry reveals a marked asymmetry, with significant dominance by Western nations. The US and the United Kingdom specialise in chip design and production automation for advanced processors, sensors, and other logic chips, placing them at the top of the production chain. Additionally, the US, the European Union, and Japan lead in chipmaking equipment and materials. South Korea, a close US defence partner, focuses on designing memory chips and manufacturing both memory and logic chips. China concentrates on fabricating mature logic chips (10 nanometres and above) and back-end manufacturing, such as assembly and testing. Taiwan, in addition to specialising in back-end manufacturing, excels in producing advanced logic chips (less than 10 nanometres). Nevertheless, no single country has the capability for end-to-end semiconductor design and manufacturing (Bauer et al., 2020).

The US dominated the semiconductor supply chain in the 1990s but gradually shifted production to East Asia, driven by lower labour and production costs (Miller, 2022; Whalen, 2021; Ziegler, 1991). Taiwanese and Chinese governments have further incentivised production by heavily subsidising domestic companies to maintain chip production locally (Whalen, 2021). With consistent demand for semiconductors across modern technologies from smartphones to satellites, governments are motivated to expand semiconductor foundries.

While semiconductors are used in various electronic devices, their industry is considered strategic technology. Though the supply chain is dominated by private companies, establishing a fabrication plant, especially for advanced chips, requires substantial investment. Consequently, state actors frequently intervene to support domestic industries and reduce dependence on foreign technologies (Drezner, 2019b). The strategic importance of semiconductors is reinforced by Drezner's and Ding and Dafoe's classifications. According to Drezner, semiconductors can be categorised as either strategic or general-purpose technologies, depending on the type of chip (advanced or mature). The semiconductor industry's oligopolistic structure, with firms such as TSMC, Intel, Samsung, and SK Hynix dominating the market, underscores its strategic importance. Ding and Dafoe further emphasise semiconductors as strategic assets based on their high entry barriers, critical role in technological diffusion, and significant dependence on a small number of firms (Ding & Dafoe, 2021, p. 198).

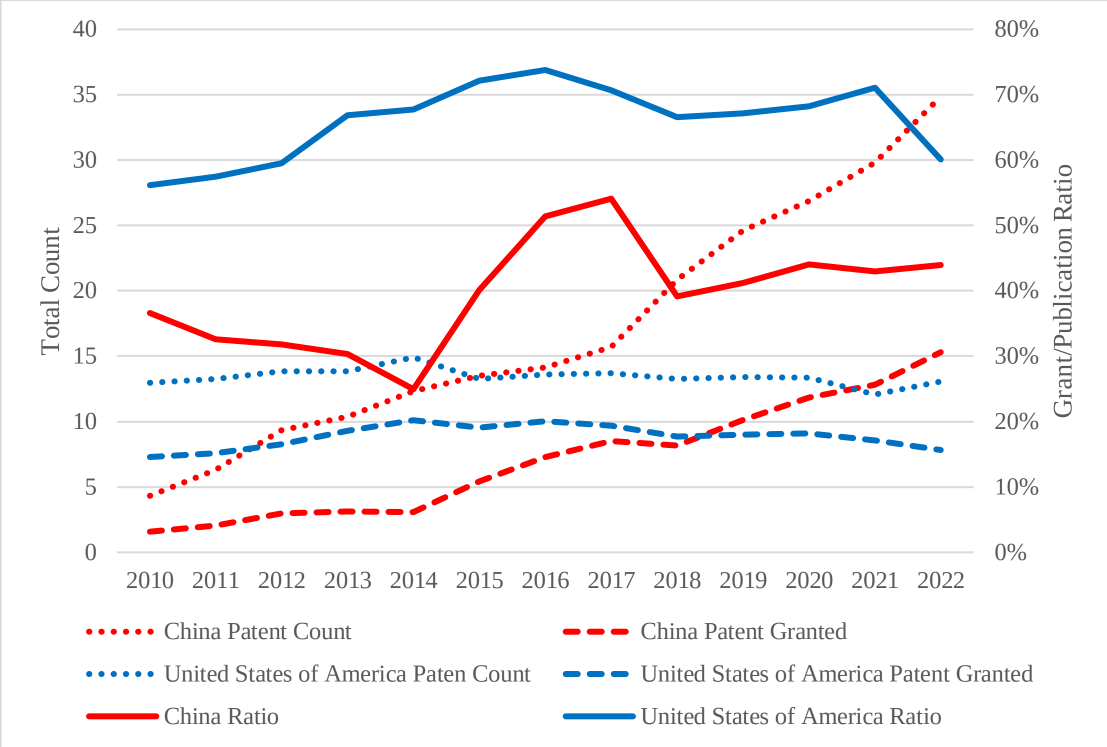
Despite widespread interest in developing or expanding semiconductor production facilities, numerous barriers make this a formidable task. First, semiconductor manufacturing requires extensive R&D investment, significant capital outlay, and rigorous operational controls to produce high-quality chips (Bauer et al., 2020). Second, the production of advanced chips depends on specialised photolithographic machines, of which ASML in the Netherlands is the sole manufacturer (O'Grady & Kenyon, 2023). Third, modern chip production involves hundreds, if not thousands, of intricate steps and requires ultra-pure raw materials (Hope, 2023; Mochizuki & Furukawa, 2023). Consequently, chip design firms often rely on established foundries, such as Taiwan Semiconductor Manufacturing Company (TSMC) or South Korea's SK Hynix and Samsung, to manufacture their products.

Semiconductors have become the strategic assets of the Fourth Industrial Revolution, much like oil was during the Third. They underpin cutting-edge technologies such as artificial intelligence (AI) and 5G telecommunications, which transform civilian and military applications alike. Furthermore, smaller chips enable greater computational power, aligning with leading sector theory, which posits that states will pursue semiconductor innovation to maintain global leadership. However, creating an entirely domestic semiconductor supply chain is a daunting challenge, given the high entry costs and the necessity of sourcing inputs from multiple countries.

The Trends in the Semiconductor Industry (2010-2022)

Intellectual property protection plays a pivotal role in the semiconductor industry as it incentivises companies to pursue innovation and invest in research and development (Chintalapodi, 2022). To secure exclusive rights and legal protection for their inventions, innovators typically apply for patents, which are registered through patent offices. A key aspect of this process is the granting of patents, wherein the patent office confers exclusive rights to the applicant, enabling them to license their invention for commercial purposes (Bailey Walsh & Co, 2024). Patent grants are subject to more rigorous scrutiny than patent publications, as they are awarded only to inventions that meet strict criteria of uniqueness, innovation, and industrial applicability. Consequently, while patent publication counts reflect the total number of inventions registered by a country, the number of patents granted provides a more accurate measure of a country's innovative capacity. In the context of semiconductor technology, patent publication and grant data are accessible through the World Intellectual Property Organisation (WIPO) IP Statistics Data Centre. By analysing the ratio of patent grants to publications, it is possible to gauge the true innovation capabilities of countries such as the US and China. This ratio offers insight into the effectiveness and quality of their technological innovations, distinguishing genuine breakthroughs from less commercially or industrially viable inventions.

Figure 1 Total Count of Semiconductor Technology Patent Total Publication (thousands), Total Grants (thousands), and Grants/Publication Ratio (2010-2022).



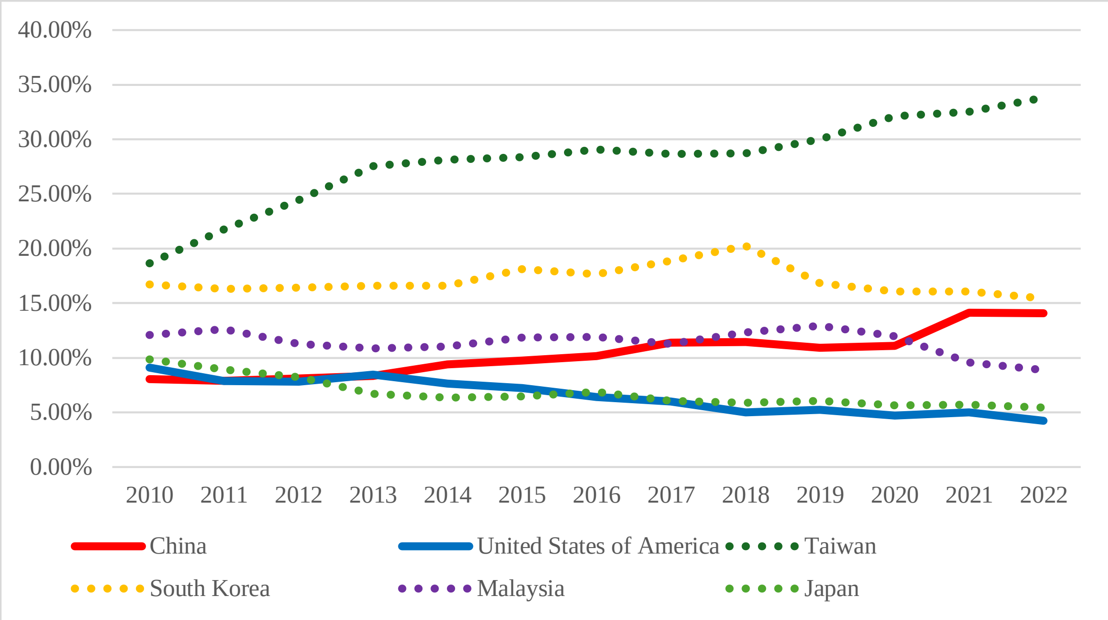
Source: Author's calculation based on WIPO IP Statistics Data Center, https://www3.wipo.int/ipstats/ips-search/patent, last updated December 2023.

Figure 1 illustrates that US patent publications in the semiconductor sector have remained relatively static over the analysed period, whereas China's output has demonstrated consistent growth. Notably, China surpassed the US in total patent counts in 2015 and, since 2020, has maintained at least double the number of publications compared to the US. A similar trend is evident in patent grants, where China overtook the US in 2019, while US figures remained largely unchanged. These trends suggest that China has been steadily increasing its production of semiconductor-related inventions since 2010, with a marked acceleration following the introduction of the Made in China 2025 (MIC2025) initiative.

However, sheer quantity does not equate to absolute dominance. The grant-to-publication ratio offers a more nuanced measure of innovation quality, and here the US outperforms China. The US has consistently maintained a grant rate of at least 55 percent since 2010, highlighting its strength in semiconductor intellectual property. By contrast, China's grant rate has remained below 50 percent for most of the period, with the exception of 2016 and 2017. Nevertheless, it is worth noting that in 2022, the US experienced a significant decline of approximately 10 percentage points in its grant rate, potentially indicating a slowdown in its semiconductor innovation. Conversely, although China experienced a steep drop in 2018, its grant-to-publication ratio has stabilised above 40 percent since then. Overall, while US semiconductor innovation remains superior, China is gradually narrowing the gap.

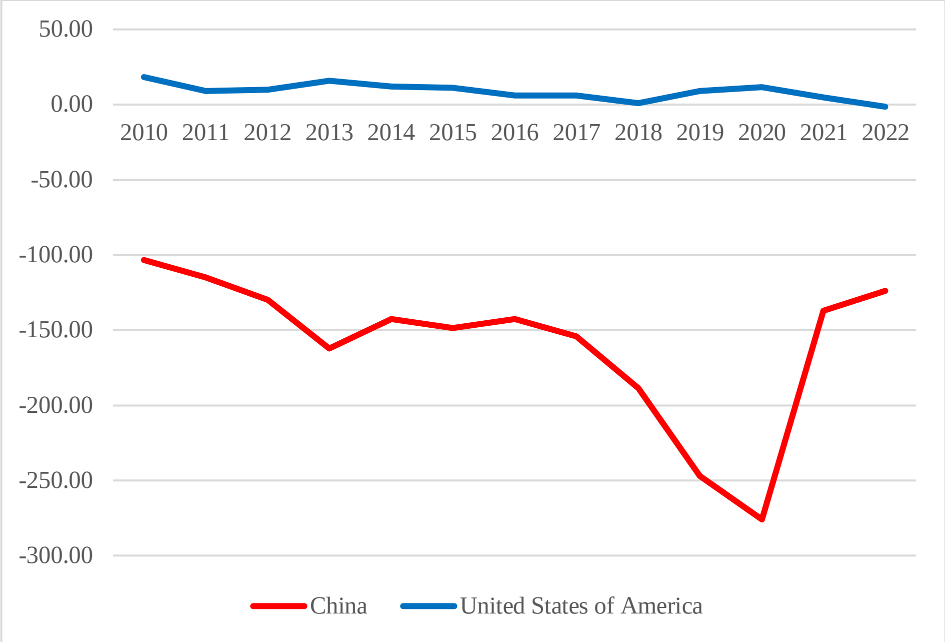
Another critical dimension of the US-China semiconductor competition is manufacturing capacity, which can be partially assessed through export data. Examining semiconductor exports offers insights into the production capabilities of both countries. To analyse these trends, the study utilised WTO data on bilateral imports categorised under Harmonised System (HS) Code 8542, which encompasses logic and memory chips. The figures were converted into global export shares to evaluate the international standing of the US and China. To contextualise these findings, key semiconductor-exporting nations, including Taiwan (Chinese Taipei), South Korea (Republic of Korea), Malaysia, and Japan, were included in the analysis. These broader trends will be explored in subsequent sections. Additionally, to provide a more comprehensive picture of the trade dynamics, the semiconductor trade balances of the US and China are also discussed.

Figure 2. Market share of semiconductor exports from 2010-2022.



Source: Author's tabulation based on WTO Stats, https://stats.wto.org/.

Figure 3. Semiconductor trade surplus (US$ billion).



Source: Author's calculation based on WTO Stats, https://stats.wto.org/.

Figure 2 shows that China's semiconductor export capacity was roughly comparable to that of the US from 2010 to 2013, but it overtook the US in 2014. Following 2013, the US global market share consistently declined, while China's share increased. By 2021, China's global market share was approximately three times that of the US. Focusing on the comparison of semiconductor trade balances between the US and China, Figure 3 reveals that China has consistently run a semiconductor trade deficit, whereas the US has typically enjoyed a surplus. Although China's deficit peaked at the onset of the COVID-19 pandemic in 2020, it halved in 2021 and continued to decrease in 2022. The US, on the other hand, saw its surplus diminish starting in 2020, and even recorded a deficit in 2022. However, the trends observed in Figure 3 between 2020 and 2022 may have been influenced by the supply chain disruptions caused by the COVID-19 pandemic.

Based on these figures, China has achieved a numerical advantage in semiconductor innovation and production over the US, but it has yet to match the US in terms of real innovation capacity. China's export share continued to grow, despite being significantly behind Taiwan and South Korea in production, and it surpassed the US in 2014. The persistent trade deficit in China's semiconductor sector highlights its ongoing reliance on foreign chip sources to support its manufacturing sector, particularly given its limited ability to produce advanced chips. Nevertheless, China has made steady and significant progress since 2018 in both innovation and trade, suggesting the successful implementation of its industrial policies. In contrast, while the US has remained the more innovative nation, there are increasingly concerning signs within the semiconductor manufacturing sector, particularly as its trade balance began to decline in 2018 and shifted to a deficit in 2022.

SECURITY AND SUPREMACY IN THE SEMICONDUCTOR INDUSTRY

The data presented in the previous section provided an overview of trends in semiconductor innovation and production in the US and China between 2010 and 2022, utilising publicly available data. This section delves further into the industrial policies implemented by the US and China to compete in the semiconductor industry. The discussion begins with China, as most experts agree that the “Made in China 2025” (MIC2025) initiative, announced by the Chinese government in 2015, catalysed the US-China technological competition. Nevertheless, the technological rivalry was formally inaugurated when Donald Trump assumed office in 2017 and initiated retaliatory measures against China. Subsequently, this section will analyse the key factors contributing to the US-China semiconductor competition.

Made in China 2025: The Quest for Semiconductor Self-Sufficiency and Dominance

The “Made in China 2025” (MIC2025) blueprint seeks to transform China into a high-tech manufacturing superpower, aiming to elevate its position within the global production value chain (Kennedy, 2015; McBride & Chatzky, 2019). The underlying objective of MIC2025 is to reduce China's reliance on foreign technology while promoting the global adoption of Chinese-made technologies (McBride & Chatzky, 2019). To achieve these goals, the Chinese government has implemented various measures, including providing subsidies to domestic technology leaders, compelling foreign firms operating in China to transfer technology, and investing in overseas high-tech companies (McBride & Chatzky, 2019; Wübbeke et al., 2016). These policies have been perceived by the US and other advocates of free markets as contravening principles of free trade and intellectual property protection.

Furthermore, China has emulated the US’ Cold War-era strategy of civil-military fusion, which harnesses technological innovation to strengthen military capabilities (Kania, 2019; Miller, 2022). In response to international criticism and fears regarding its technological ambitions, the Beijing government has softened the public rhetoric surrounding MIC2025. However, it remains resolute in its pursuit of global leadership within the semiconductor industry.

Achieving self-sufficiency in semiconductor production and reducing dependence on foreign suppliers are critical objectives of MIC2025. The outbreak of the COVID-19 pandemic in 2020 exacerbated China’s challenges in this sector, as the country struggled to secure advanced chipmaking equipment (Ji, 2023; Yamada, 2023). Reports indicate that China currently produces less than 20 percent of its semiconductor requirements, relying heavily on foreign sources to sustain its manufacturing sector. This dependence has hindered progress towards its target of achieving 40 percent self-sufficiency by 2020 (Tabeta, 2021; Yamada, 2023). Data from the World Trade Organization (WTO) reveal that China imports the majority of its semiconductors from Taiwan and South Korea, accounting for over 50 percent of its total imports.

Another significant challenge for China is the lack of access to deep ultraviolet (DUV) photolithography machines, essential for producing advanced chips. The COVID-19 pandemic severely disrupted the global supply chain, exacerbating this issue. Moreover, the situation was worsened by the Biden administration’s export control measures introduced in October 2022, which were subsequently supported by the Netherlands and Japan (Petrakakos, 2023). Given that the Netherlands is the sole producer of DUV photolithography equipment, restrictions imposed by the US have significantly hindered China’s access to these machines. This technological bottleneck could delay China's advancements in semiconductor manufacturing by decades, potentially limiting its capabilities to producing only mature chips and slowing its quest for leadership in the semiconductor sector.

Despite these challenges, China retains an advantage in the production of technologically mature goods. While it continues to rely on Western nations for advanced semiconductor supplies and processes, China has made significant progress in other industries. It has demonstrated rapid growth in the production of advanced machine tools, electronic products, electric vehicles, and telecommunication infrastructure, establishing itself as a leader in these sectors (Ghiasy & Krishnamurthy, 2021; Lee, 2020; Wang, 2023).

Additionally, China leads in the manufacturing of solar panels and high-capacity batteries for green vehicles (Wang, 2023). This manufacturing dominance is underpinned by substantial government subsidies and extensive labour expertise, acquired through decades of production offshored from Western companies (Wang, 2023, pp. 70–73). These factors enable China to optimise and coordinate all stages of the innovation process (Allen, 2023), leveraging its workforce experience (Wang, 2023) to bolster its innovative capacity. Although the US remains at the forefront of artificial intelligence and quantum computing innovation, China is gradually closing the gap (Allison et al., 2021; Schmidt, 2023).

The US: From Trade War to Technology Competition

Donald Trump initiated a trade war against China and ordered an investigation into China's alleged unfair trade practices following his inauguration as the 45th President of the United States of America. While Trump primarily focused on addressing overall trade imbalances, the US Trade Representative's Section 301 investigation found that China engaged in practices such as forced technology transfer and intellectual property theft, undermining the US technology sector (Rogin, 2018). In response, the US government imposed additional tariffs on Chinese products and restricted foreign investment in China as defensive measures (Rogin, 2018).

Several incidents provoked the US to adopt retaliatory actions. First, the US government uncovered that Chinese telecommunications companies ZTE and Huawei had covertly supplied Iran with telecommunications equipment, violating international sanctions (Shepardson, 2019). Furthermore, Beijing's policies of forced technology transfer, industrial espionage, cybertheft, and investment in critical technology companies posed a significant threat to US national security (Demarais, 2022). As technology constitutes a cornerstone of the US economy and defence strategy, such practices risk undermining US national power and security. Concerns have also been raised regarding potential "backdoors" embedded in Chinese technologies, enabling the Chinese government to access US intelligence (Demarais, 2022). Second, China's implementation of the Digital Silk Road has been viewed as a strategy that could diminish US global leadership (Edel & Rapp-Hooper, 2020). China surpasses the West in technology exports, offering cost-effective solutions, particularly in 5G and mature chip technologies. However, its efforts to expand 5G networks and build data centres worldwide have raised fears that these could evolve into global surveillance systems, enabling the monitoring of internet data on a massive scale (Edel & Rapp-Hooper, 2020).

In addition to competition with China, the COVID-19 pandemic further propelled the US into a heightened focus on technological competitiveness. The pandemic disrupted global supply chains, exposing the vulnerabilities of the US economy's reliance on China and East Asia for semiconductor supplies (Simchi-Levi et al., 2022). This disruption significantly impacted the US economy, particularly the automotive and IT industries (Bauer et al., 2020; Klayman & Nellis, 2023). Consequently, the US introduced policies to incentivise the return of chip manufacturing to the country and to attract leading foreign semiconductor manufacturers to establish fabrication plants domestically.

The Biden administration enacted the CHIPS and Science Act in 2022 to promote self-sufficiency in semiconductor production and strengthen supply chain resilience. The act allocates funding to US chipmakers to expand domestic manufacturing capacity and enhance semiconductor research initiatives. Its objectives include reinforcing the US semiconductor industry, bolstering supply chain resilience, and countering perceived threats from China (Antsey, 2022; Simchi-Levi et al., 2022). This "Small Yard, High Fence" strategy explicitly targets China, aiming to preserve US global technological leadership, strengthen the semiconductor supply chain, and gain a competitive edge in frontier technology research. Adding further pressure on China, the Biden administration introduced export control measures designed to restrict China's access to advanced semiconductor technologies and chipmaking equipment (Iyengar, 2022).

Security and Supremacy

The wide-ranging applications of semiconductors and their capacity to drive innovation make them a strategic commodity and technology. Moreover, applying the arguments of leading sector theorists, countries involved in the semiconductor supply chain are likely to prosper, particularly the US, which dominates semiconductor design and equipment provision. Although China is a latecomer to the semiconductor industry with limited capacity to produce advanced semiconductors, its formidable manufacturing capabilities hold the potential to significantly influence the global economy. However, the fragmented nature of the supply chain where different countries specialise in specific segments has exposed both the US and China to economic vulnerabilities. Consequently, security and leadership have emerged as the primary motives driving US-China competition in the semiconductor industry.

China has sought to achieve technological self-sufficiency and global leadership through its Made in China 2025 initiative. Its goal is to establish an indigenous semiconductor supply chain capable of manufacturing advanced chips, thereby sustaining its high-tech sector without reliance on foreign sources, thus safeguarding its economy. However, China's ambitions also reveal revisionist tendencies, as it aims to dominate the semiconductor supply chain and increase global dependence on its technologies. As illustrated in Figures 1 to 3, China has already surpassed the US in semiconductor manufacturing capacity and continues to grow. Nevertheless, it lags in innovation and remains dependent on external sources for advanced chips to sustain its high-tech manufacturing sector. While these efforts may secure China's economy in the short term, achieving technological supremacy appears unattainable under current conditions, particularly given the stringent export controls imposed by the US.

The US' engagement in technological competition with China is driven by several factors, including internal security concerns and the desire to maintain technological leadership. First, the US government harbours genuine fears that Chinese technologies and industrial policies could directly threaten its national security or military capabilities. Second, the US experienced significant economic repercussions from the chip shortages during the COVID-19 pandemic, which exposed vulnerabilities in its reliance on foreign supply chains. Third, there is growing concern within the US that it is losing its leadership position in the global semiconductor industry to China. In response, the US leverages its dominant position in the upstream segments of the supply chain and its close partnerships with other major semiconductor-producing nations to restrict China's access to advanced semiconductors and chipmaking equipment.

The role of other key actors in the semiconductor supply chain is crucial to the dynamics between the US and China. As illustrated in Figure 2, Taiwan and South Korea remain the two largest semiconductor producers in terms of market share. While China may soon rival South Korea, it is unlikely to reach Taiwan's level in the near future. Notably, with the exception of Malaysia, China has experienced significant geopolitical tensions with other major semiconductor-producing nations. Despite these tensions, Taiwan, South Korea, and Japan have aligned closely with the US motivated by shared concerns over national security and economic stability. This alignment has resulted in collective efforts to limit China's access to advanced chips and technologies, thereby curtailing its technological growth and moderating its assertive behaviour.

The US also seeks to bolster the West's collective dominance in the semiconductor supply chain. In response to the disruptions caused by the COVID-19 pandemic, the US proposed an alliance with Taiwan, Japan, and South Korea to strengthen the semiconductor supply chain (Blanchard, 2023). President Biden further proposed the informal CHIP4 Alliance, bringing together the largest semiconductor manufacturers (Taiwan, Japan, and South Korea) (Blanchard, 2023; Hsu, 2022). The CHIPS Act has also incentivised leading foreign semiconductor fabrication companies, such as TSMC, Samsung, and SK Hynix, to establish production facilities within the US or strengthen collaboration (Kreps et al., 2022). Although these key players have aligned with US efforts to restrict semiconductor technology and advanced chipmaking equipment from China, they express concerns about the long-term economic implications. They fear that stringent US restrictions might inadvertently accelerate China's drive for technological self-sufficiency, enabling it to emerge as a major technological power without external assistance (Evers, 2024).

CONCLUSION

Countries pursue technological power to enhance their economic capabilities and military strength. A state capable of proliferating its technology can assert global leadership, either through the dissemination of its technological advancements or by controlling international standards. Semiconductors, being central to modern technological power, have become a focal point for the US and China, both of which aim to dominate the semiconductor supply chain. Moreover, lessons from supply chain disruptions that severely impacted their economies have driven both nations to reduce vulnerabilities in this critical industry. In summary, security concerns and hegemonic ambitions have propelled the US and China into the current technological competition, although both remain cautious to prevent its escalation into armed conflict.

Through the Made in China 2025 initiative, China aims to increase its self-reliance in semiconductor production and achieve dominance in the chipmaking industry. Despite substantial investments in this sector, China has struggled to enhance its chipmaking capacity and continues to rely heavily on foreign sources for advanced chips and chipmaking equipment. The prospects for China to achieve technological hegemony appear bleak, particularly following extensive efforts by the US to restrict its access to advanced semiconductors and related technologies.

The US entered the technological competition to safeguard its national security and economic interests, particularly after identifying China's unfair trade practices as a threat to its technology sector. Although the US retains leadership in the semiconductor industry, it has already ceded much of its manufacturing capacity. The COVID-19 pandemic exposed the risks of overreliance on the East Asian semiconductor supply chain, prompting the US to bolster its supply chain resilience through the CHIPS and Science Act. Additionally, the US has leveraged its dominant position in the upper echelons of the semiconductor supply chain to reinforce its leadership and exert pressure on other nations to curtail China's advancement in semiconductor technologies.

This article offers a foundation for future research. First, it examines trends only up to 2022, prior to the observable effects of the CHIPS and Science Act and before the intensification of the US-China rivalry. Future studies could expand upon this work to analyse how US and Chinese policies have shaped the competition since 2022. Second, this article primarily focuses on the US-China semiconductor competition from the perspectives of innovation and manufacturing. A broader analysis could be achieved by incorporating trends in chipmaking equipment and other facets of semiconductor production, such as raw materials. Third, given that the competition will inevitably draw in other key players in the semiconductor industry, it is essential to explore how this rivalry impacts them, including their decisions to align with either the US or China or to maintain a balance between the two. Finally, this article would benefit from further exploration through the lens of established international relations theories to provide a more robust theoretical framework.

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