Charting the future of the global semiconductor industry and Thailand's next moves.

19 September 2023

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KEY SUMMARY

The semiconductor industry continues to struggle with supply and demand imbalances, exacerbated by a surge in demand and disruptions in the manufacturing supply chain.

Global demand for semiconductors is expected to continue to surge as numerous countries shift toward digital economies. However, a series of events have disrupted the supply of semiconductors, including the China-US trade war, which escalated into a technology war, the COVID-19 pandemic, and the Russia-Ukraine dispute that resulted in surging raw material prices. While the imbalance has somewhat eased with the resumption of increased production capacity and output, the market dynamics and the balance between supply and demand still require close, ongoing monitoring as demand is poised for yet another surge, driven by the gradual recovery of global economic conditions. Conversely, the semiconductor manufacturing supply chain remains vulnerable to a multitude of risks.

Such imbalances have prompted many countries to prioritize securing chip manufacturing and promote domestic production.

Currently, many countries are vigorously securing and strengthening their domestic semiconductor industry. Prominent examples include the US and the EU, both of which have enacted the CHIPS Act, with an aim to boost domestic semiconductor production. Similarly, Asian manufacturers are firm in maintaining their semiconductor production positioning, which includes resorting to trade retaliatory measures. A notable example is China, with retaliations against technological barriers imposed by the United States. Nonetheless, several challenges continue to hinder China's semiconductor industry development. Most notably, domestic production volumes still fall short of meeting local demand. Furthermore, many countries have relocated manufacturing of specific semiconductor and parts to other countries, with a notable focus on the Asian region, renowned for its production capabilities.

SCB EIC views that the relocation of foreign semiconductor production facilities to Thailand will play a pivotal role in enhancing the nation's capabilities to become both a front-end and back-end semiconductor manufacturer in the future.

As a new global production supply chain takes shape, several production facilities are expected to relocate to Thailand, accompanied by increased investments in the semiconductor and parts manufacturing sector. SCB EIC anticipates that Thailand's chip industry holds the potential for further advancement, especially in front-end and higher complexity back-end processes. Meanwhile, a group of Thai companies exporting semiconductor and parts to China may experience a decline in orders due to US trade barriers. Nevertheless, SCB EIC views that increased investments in Thailand's semiconductor industry will have a far-reaching positive impact on domestic employment, eventually giving rise to a new production supply chain that can better serve the domestic market.

Nonetheless, Thai companies need to embrace change, either by forming new alliances or strengthening own capabilities to adapt to evolving demands.

Future development of Thailand's semiconductor sector remains challenging, primarily due to technological constraints and substantial investment prerequisites. Thai companies aspiring to be an integral part of the new semiconductor production supply chain must get into the swing of things by implementing these recommended strategies: 1) Establishing collaborations with governmental bodies and private entities to fortify strength within the semiconductor manufacturing industry. 2) Actively looking for joint venture opportunities with new partners and/or co-investors by capitalizing on the advantages of relocating production bases. 3) Strengthening domestic semiconductor production capabilities through increased focus on research and development and 4) Promoting workforce skills development, both hard and soft skills, to align with the future, evolving demands in the semiconductor industry.

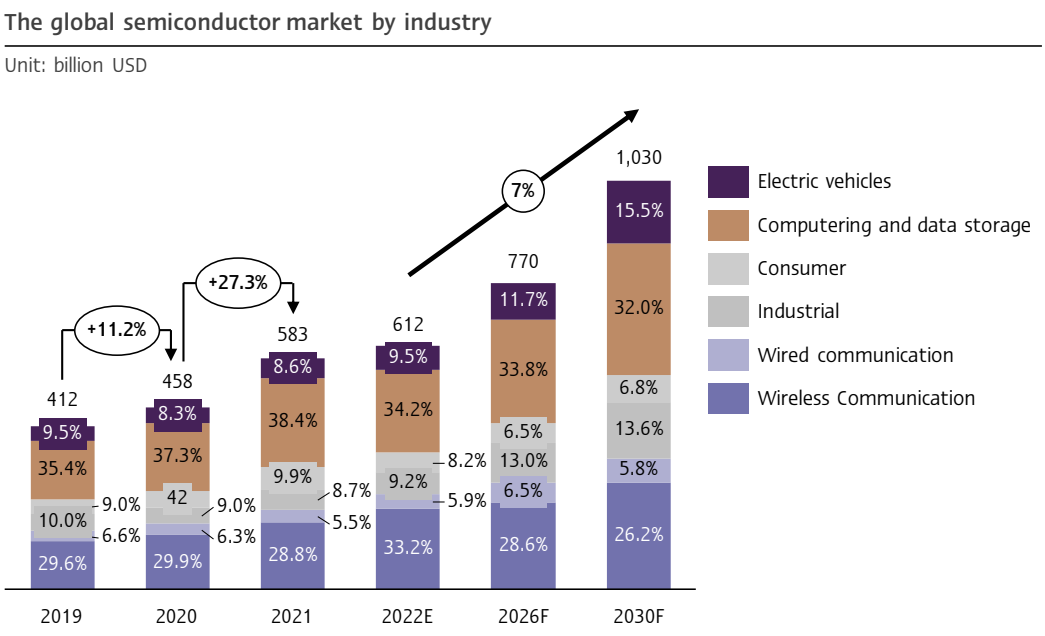
What causes imbalances in the global semiconductor market?

The global semiconductor industry continues to struggle with persistent supply and demand imbalances. Such conditions arise following a significant surge in demand, coupled with disruptions in the manufacturing supply chain attributed to a multitude of factors, including the US-China trade war, the COVID-19 pandemic, and the prolonged and intensifying geopolitical tensions.

The global semiconductor industry is experiencing a surge in demand, driven by the rapid proliferation of digital technology trends and shifts in consumer preferences. **Today, semiconductors have become an increasingly indispensable component in the production of a wide array of downstream products spanning various sectors.** These products include tablets, computers, smartphones, electrical appliances, and electric vehicles. Since the onset of the COVID-19 pandemic in late 2019, consumer demand for computer and parts has witnessed a remarkable upswing, fueled by the work-from-home and online learning trends. Additionally, the broader integration of Artificial Intelligence (AI) technologies, encompassing applications such as autonomous vehicle systems, ChatGPT, and advanced data analytics for in-depth industry analysis and predictions, has also amplified the demand for semiconductors.

Moreover, the demand for semiconductor has witnessed exponential growth, notably driven by surging popularity of electric vehicles (EVs) in the global market. Research indicates that, on average, a single electric vehicle requires over 3,000 semiconductor chips. SCB EIC views that digital technology trends and shifts in consumer behaviors are driving a rapid increase in demand for semiconductors on the global stage. Under these prevailing conditions, businesses are compelled to expedite the development of innovative products to meet consumer needs. Such trends mirror data from McKinsey & Company, which indicates sustained growth in the global semiconductor demand across various industries, allowing the market value to expand in 2020 and 2021 by 11.2% YOY and 27.3% YOY, respectively. From 2022 to 2030, such growths should average at 7% per year, mainly driven by demand in key sectors, including electric vehicles, computing and data storage, and wireless communication industries, respectively (Figure 1).

Figure 1: The market value of the semiconductor industry continues to grow in 2030, especially from electric vehicle industry.



Source: SCB EIC analysis based on data from McKinsey & Company.

The onset of the global semiconductor shortage can be traced back to the trade war between China and the US in 2018, which subsequently escalated into a technology war. In 2019, the US government took the step of canceling imports of communications equipment to restrict the use of Huawei's 5G technology due to concerns over data security, particularly sensitive military data access. Such actions had ripple effects across industries, leading to supply shortages for companies reliant on parts and equipment from Huawei. Prominent names affected by such actions included TSMC, BYD, and Foxconn. These tensions persisted and intensified in 2022 when China's Semiconductor Manufacturing International Corporation (SMIC), a key player in the Chinese chip manufacturing industry, faced import restrictions on machinery and equipment crucial for producing advanced chips. Concurrently, the US blacklisted China's NAND flash semiconductor producer YMTC. As such, these developments influenced tech giant Apple to pivot from its initial plans of using Chinese chips (YMTC) to opting for South Korean chips (Samsung) instead.

The emergence of the COVID-19 pandemic towards 2019 year-end significantly worsened the already precarious chip shortage conditions, especially during periods of strict lockdowns aimed at curbing the virus's spread. Consequently, activities in the global chip production supply chain, including transportation and logistics, came to a sudden stop. Furthermore, China's strict Zero-COVID policy further prolonged delivery times of semiconductors, inevitably hampering various downstream industries, especially those that required advanced manufacturing technologies, such as electronics and automotive industry.

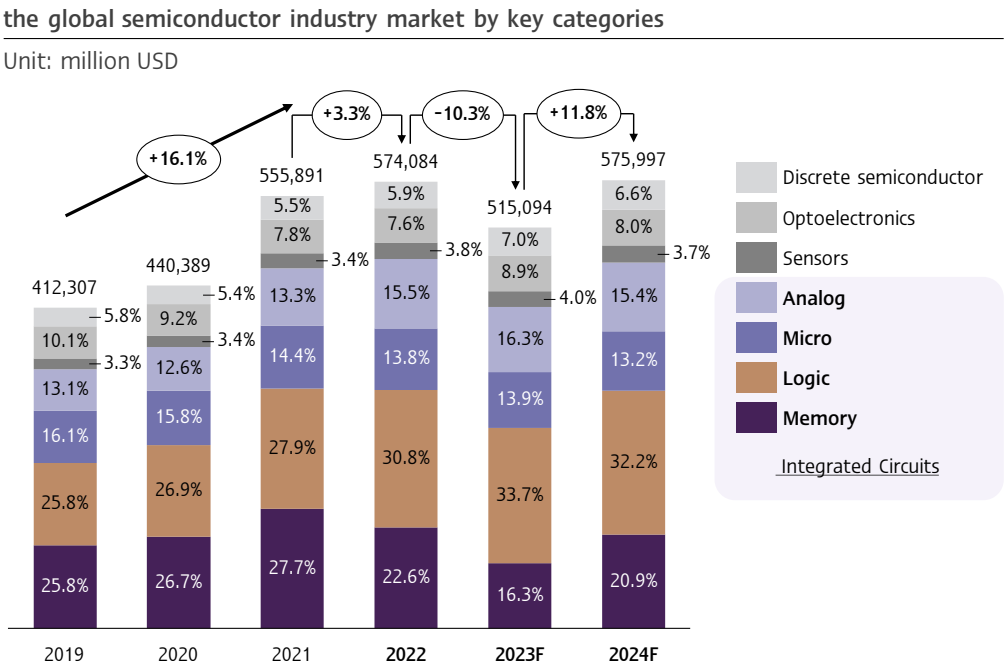
Moreover, the conflicts between Russia and Ukraine exerted upward pressure on raw material costs in semiconductor production. Both Russia and Ukraine are primary suppliers of critical materials related to upstream semiconductor production, including neon gas and palladium. Ukraine, in particular, supplies approximately 70% of the global purified neon gas production, while Russia supplies roughly 40% of global palladium production. As a result of this tension, exports of neon gas and palladium saw a substantial decline, leading to a surge in market prices for these crucial raw materials. For instance, the price of palladium witnessed a notable increase, rising from 1,900 USD/ounce in early 2022 during the prelude of the war, to a peak of 3,440 USD/ounce by March. Fortunately, this upward trajectory began to reverse in April last year, as major semiconductor manufacturers in Asia identified new sources of palladium outside of Russia.

Looking ahead, challenges of global imbalance warrants close monitoring despite improving situation in the short term amid a weakening global market demand alongside increased supply. SCB EIC anticipates that in 2023, the global semiconductor sales will continue to decline further from 2022. This could be attributed to lower demand for memory chips within consumer electronics (smartphones, computers, and notebooks), in tandem with lackluster global economic conditions. On the flip side, semiconductor supply has gradually rebounded due to easing COVID-19-related disruptions and the identification of alternative sources of critical raw materials. Such better production conditions could be reflected

by the sustained reductions in global semiconductor delivery times. With such regards, we expect that the chip shortage conditions should be resolved by the end of 2023 (Figure 3).

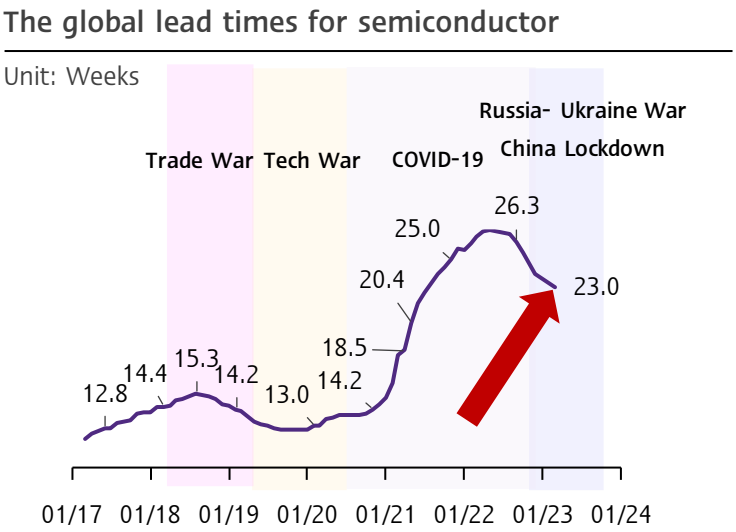
Nevertheless, the supply and demand imbalances in global chip production warrant close monitoring in the periods ahead. The demand for various semiconductor products should continuously improve, particularly in logic chip products. The mentioned chips serve as the brains behind electronic devices and are integral in various industries, including the electric vehicle sector. According to The World Semiconductor Trade Statistics (WSTS), the global semiconductor industry's market size is projected to rebound with an impressive 11.8% YOY growth in 2024, following an anticipated contraction of -10.3% YOY in 2023 (Figure 2). As demand potentially rebounds, developments within the world semiconductor production supply chain should be closely monitored, especially the aftermath impacts of the technology war between the US and China.

Figure 2: Global sales of semiconductors is expected to expand in 2024 backed by recovering global demand.



Source: SCB EIC analysis based on data from the World Semiconductor Trade Statistics (WSTS).

Figure 3: Chip shortage conditions should continue to ease gradually as evidenced by shorter delivery time.

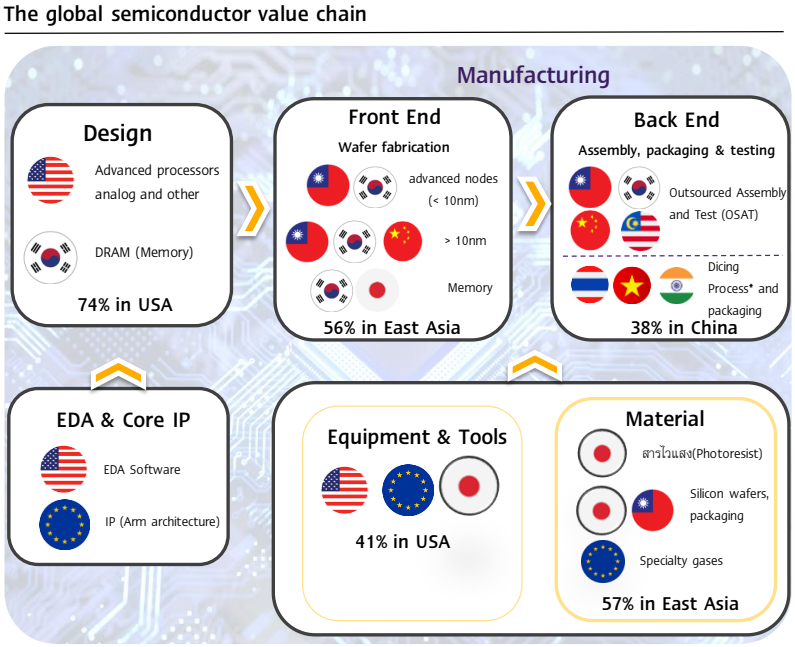


Source: SCB EIC analysis based on data from Bloomberg.

What's next for the global semiconductor supply chain?

Currently, the world's major semiconductor manufacturers remain concentrated in Asia, particularly those specializing in advanced chip manufacturing. This concentration in Asia persists because industry leaders in Taiwan and South Korea have consistently invested in cutting-edge technology to advance the semiconductor manufacturing process. To provide a comprehensive view of the manufacturing landscape within the global semiconductor value chain, it is essential to recognize 3 integral groups of players: 1**) Product Designers (Fabless)**, companies in this category focus on product design and distribution. Notable players include US-based companies, such as Qualcomm, Apple, NVIDIA, and Micron. While Fabless players excel in product development, they typically avoid investing in manufacturing technology. **2) Foundries (Front-End Process)**, companies in this category are responsible for wafer fabrication and include key players from Taiwan (TSMC), South Korea (Samsung), and China (SMIC). Players in this group heavily invest in advanced technology and procure machinery from equipment and tools manufacturers, such as Netherlands (ASML), which custom-produces machinery based on orders from product designers (Fabless), and **3) Outsourced Semiconductor Assembly and Test (OSAT)**, currently, OSAT back-end service providers exhibit greater diversity, with operations spread across ASEAN countries, including Thailand (Figure 4).

Figure 4: The global semiconductor value chain



Source: SCB EIC analysis based on data from SIA, Accenture, and Deloitte Insights.

When categorizing manufacturers by technology classification, the latest analysis in 2022 reveals that, Taiwan (TSMC) dominates the global semiconductor production, contributing to 47% of the production of 12-inch semiconductors silicon wafers and an impressive 78% of the production of advanced semiconductors below 7 nanometers. Taiwan (TSMC) boasts a semiconductor wafer production capacity of approximately 10 million unit per year, with key collaborative partners including Apple, Nvidia, Qualcomm, and Intel. The remaining is shared between South Korea and China, constituting 21% and 1% of the overall advanced semiconductor production, respectively (Figure 5 and 6). In South Korea (Samsung), the components primarily target smartphones and tablets within the company's product portfolio. Additionally, a notable portion of Samsung's chip production serves as integral parts for the renowned EV manufacturer, Tesla. In contrast, China (SMIC), maintains its focus on the production of 12-inch semiconductors silicon wafers and semiconductors exceeding 7 nanometers. This orientation is prompted by China's restricted access to advanced semiconductor manufacturing technology and equipment, resulting from trade barriers imposed by the United States.

Currently, Taiwan (TSMC) holds a commanding position in the production of both 12-inch semiconductors silicon wafers and advanced semiconductors below 7 nanometers.

Figure 5: Asia takes center stage as the primary global manufacturer, particularly in advanced process semiconductors.

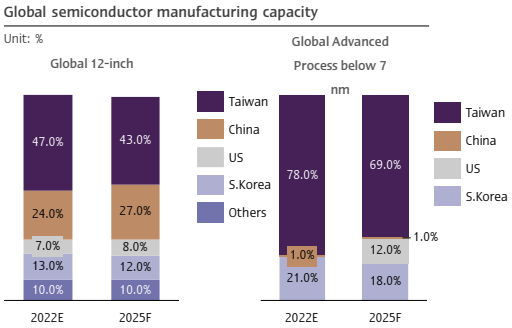
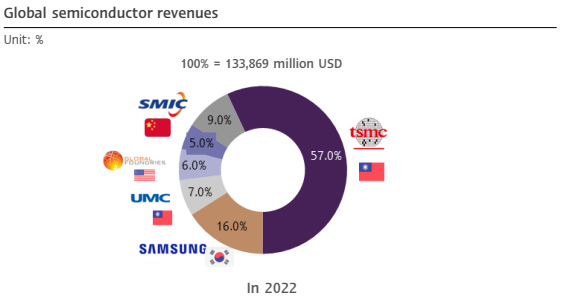


Figure 6: TSMC, a Taiwan-based semiconductor manufacturer, emerges as the top revenue earner on a global scale.



Source: SCB EIC analysis based on data from Trendforce

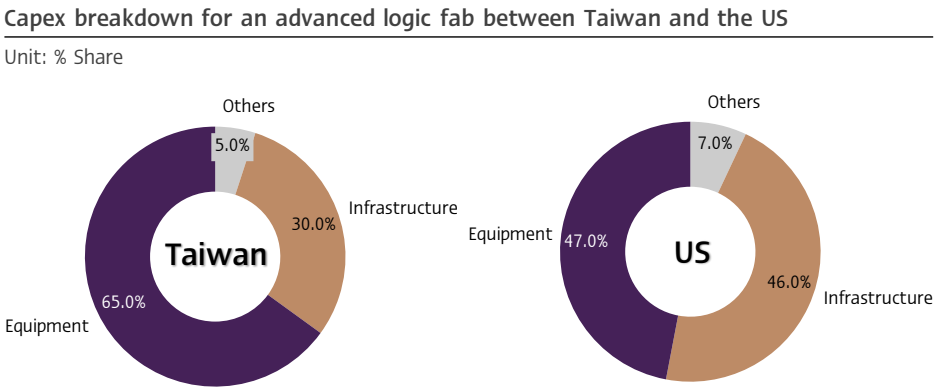
One of the main consequences of the tech war is the pushing force to relocate advanced semiconductor production, specifically those below 7 nanometers, out of Asia. Notably, there is a projected increase in the share of advanced semiconductor manufacturing in the US, at 12% by 2025, aligning with the country's national strategy aimed at strengthening domestic semiconductor production (Figure 5). The US government has been actively encouraging companies to reshore their manufacturing operations to enhance resilience in the face of imbalances in the production supply chain and dependence on Asian manufacturers. As such, in August 2022, the US government has passed the CHIPS Act, which includes subsidies and tax incentives designed to boost investments in the US semiconductor industry. Such incentives cover various areas of supporting measures, including research and development initiatives, workforce training within the production domain, and collaborative partnerships with allied governments. Thanks to these appealing incentives, major semiconductor manufacturers like TSMC, Intel, Samsung, Micron, and other industry leaders have unveiled investment plans that involve expanding semiconductor production capacity within the United States.

Nevertheless, such regulations also bring about further constraints for semiconductor manufacturers planning to invest in the US by prohibiting such companies receiving US funding from engaging in advanced semiconductor manufacturing below 28 nanometers in China for a duration of 10 years. Consequently, in early July 2023, a leading US semiconductor manufacturer petitioned the government to reconsider measures related to chip exports and the provision of semiconductor production equipment to China from the concern that the stringency of these regulations may block American semiconductor manufacturing companies from conducting business in China. Moreover, there is potential for such restrictions to expand to other semiconductor types in the future.

However, the US strategy to reshore semiconductor production inevitably faces numerous obstacles and challenges, with a significant concern centering on the scarcity of highly skilled workers in the manufacturing sector. As part of the effort to strengthen the domestic semiconductor industry, over 50 projects linked to the emerging semiconductor production supply chain have been initiated, amassing a collective investment of approximately USD 210 billion. Many companies are currently involved in the construction of semiconductor manufacturing plants (Fabs), with plans to commence production by as early as 2024. Such projects are expected to create a surge in demand for skilled workers within the newly established facilities, potentially necessitating the creation of around 70,000 to 90,000 positions. However, meeting such requirements poses a big challenge for the US, as the country must be able to supply adequate labor to satisfy the demand from both new factory construction and the provision of proficient personnel for the semiconductor production process. Despite the integration of advanced technology and automation within semiconductor manufacturing plants, the presence of highly skilled workers remains essential for overseeing the intricacies of the production process.

Additional challenges for manufacturing semiconductors in the US include higher labor and upstream raw material costs, which continue to surpass the cost in Asia. According to TSMC, producing the same semiconductor type in the US will result in approximately 50% higher in labor and raw material costs compared to production in Taiwan. Such heightened costs align with Goldman Sachs' assessment of minimum wage rates and expert engineer salaries in the United States versus Taiwan in 2022. The key insights from this assessment include 1) the minimum wage in the United States averaged at 11.25 USD/hour, significantly surpassing those in Taiwan at 5.25 USD/hour and 2) the remuneration of expert semiconductor engineers in the United States averaged at 115,000 USD/year, in stark contrast to Taiwan's 30,600 USD/year, or 3.8 times higher (Figure 7). Such escalated costs will exert downward pressure on the profit margins of companies planning to invest in the US in the foreseeable future. Furthermore, higher manufacturing costs in the US also result from shipping costs incurred while importing raw materials and consumable supplies from Asia, as crucial elements of the upstream semiconductor manufacturing supply chain remain predominantly situated in Asian region. In conclusion, raw material and consumable costs are projected to be approximately 5% higher when semiconductors are produced in the US.

Figure 7: The cost of manufacturing semiconductors in the US is 2 times higher than Taiwan, primarily due to elevated labor and raw material expenses.



Source: SCB EIC analysis based on data from Goldman Sachs.

Similarly, the European Union also introduces policies to stimulate semiconductor production within its borders, exemplified by the enactment of the European Chips Act, designed to reduce reliance on imports. The European Union has earmarked an enormous investment budget exceeding USD 47 billion to foster collaborative investment initiatives among countries in the European Union and partner countries, particularly in the domains of research, design, and advanced computer chip testing. The ultimate goal is to increase semiconductor production capacity within the EU area from currently 10% of global semiconductor production to 20% by 2030. Notably, Intel has recently unveiled plans to invest in Germany, Israel, and Poland, amounting to a total investment of USD 62.6 billion. Concurrently, TSMC is engaged in discussions with the German government to secure subsidies for the construction of a semiconductor manufacturing facility in Germany. Besides, the European Union also benefits from a unique advantage, as the Netherlands (ASML) is the sole manufacturer capable of producing EUV lithography machines essential for advanced semiconductor manufacturing. In early 2023, the Netherlands and Japan reached an agreement with the United States on plans to impose restrictions on the export of advanced semiconductor manufacturing equipment to China. The United States cited security concerns related to China's intended utilization of advanced semiconductors for military purposes. Consequently, some of ASML's suppliers have formulated plans to relocate their production bases from China to Southeast Asia, mitigating potential conflicts between the United States and China.

Apart from the US and EU's endeavors to localize semiconductor manufacturing, Asian manufacturers are also taking concerted actions to fortify their semiconductor production capabilities. The South Korean government, for instance, has introduced the K-Chips Act, signaling its intention to invest substantially in chip manufacturing. This commitment encompasses financial support of approximately USD 230 billion, by increasing the tax credit

for corporates from 8% to 15% and from 16% to 25% for small and medium-sized companies. One of the main objectives is to propel South Korea to be one of the world's semiconductors manufacturing powerhouse, thereby securing a competitive advantage in the global market over the long run. However, South Korea still have remained concerns about the US–China conflict, especially about potential ramifications on South Korean semiconductor exports. South Korea views that the US may need to temper some of its regulations to mitigate the impact on the global semiconductor production supply chain. Moreover, China is still currently considered an important trading partner and supplier to South Korea. Additionally, South Korea has joined the CHIP 4 alliance, comprising the United States, Japan, and Taiwan, to preserve the adaptability of the semiconductor supply chain. **Meanwhile, other leading semiconductor manufacturers such as Taiwan (TSMC) are actively striving to bolster their production bases by fostering domestic semiconductor manufacturing and expanding operations to encompass more partner countries.** The Taiwanese government has promoted domestic semiconductor production by increasing tax credit for local companies' investments in semiconductor research and development from 15% to 25%. Furthermore, Taiwan provides additional tax incentives for manufacturers of new equipment tailored for advanced process semiconductor manufacturing.

Nevertheless, the prolonged conflict between China and Taiwan has raised mounting concern for Taiwan about potential disruptions to its advanced semiconductor manufacturing supply chain. While Chinese authorities have not yet implemented serious measures against Taiwan, given their ongoing reliance on semiconductors from the region, there exists a looming possibility of supply chain disruptions should the conflict escalate in the future. Furthermore, Taiwan's semiconductor production remains vulnerable to natural disasters. In 2021, Taiwan grappled with a severe drought and acute water shortage, impacting various sectors, including the agricultural and industrial sectors. The semiconductor manufacturing industry was harshly affected, as the industry requires substantial water resources throughout its production process. Consequently, Taiwanese manufacturers, such as TSMC, have undertaken efforts to expand their semiconductor manufacturing investments in the United States and the European Union. Such a strategic move aims to mitigate the potential risks associated with semiconductor shortages in the future.

Turning to China, the country has responded to technological bans imposed by the United States and its allied nations with trade retaliatory measures. Notable among these measures are **1) Banning Chinese companies from procuring specific products from the US-based company Micron**, including memory chips extensively used in smartphones, computers, and electronic devices. This prohibition stems from concerns related to cybersecurity and national security, and **2) Imposing restrictions on the export of two types of minor metals**, announced in early July 2023 and set to take effect from August 1, 2023. These minor metals hold considerable significance as essential raw materials in the upstream semiconductor manufacturing process. The anticipated consequences of limiting gallium and germanium exports to the US may result in potential disruptions to the US semiconductor production supply chain as well as an escalation in upstream raw material costs for semiconductor manufacturing.

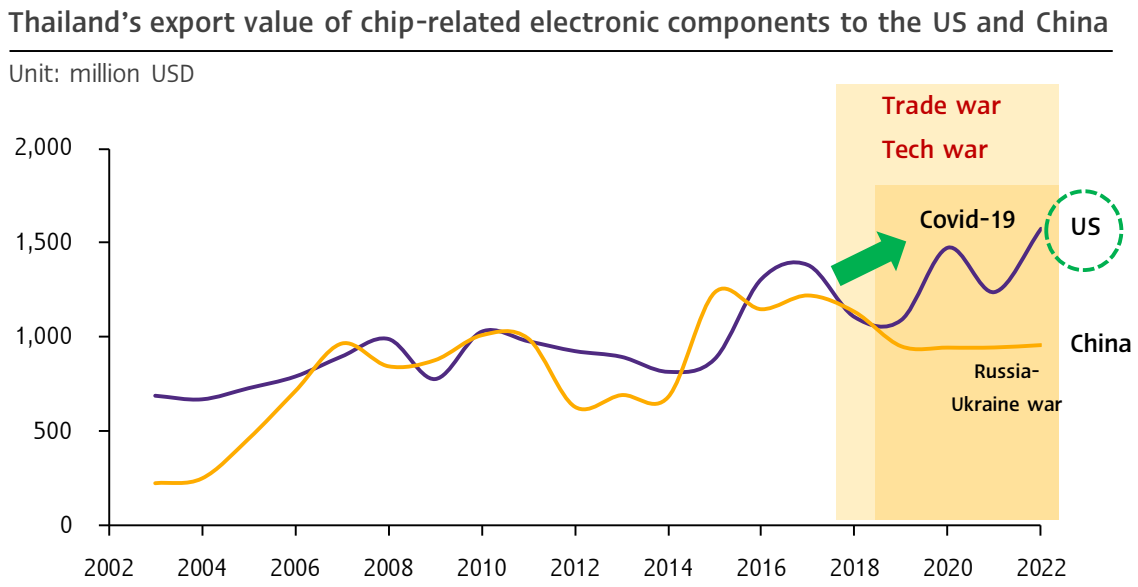
Nonetheless, several challenges continue to impede the progress of China's semiconductor industry development. Notably, domestic production volumes still fall short of meeting the local demand for semiconductors. According to data from Goldman Sachs, in 2022, domestic demand for semiconductors from China's manufacturing sector accounted for approximately 35% of total global demand, while Chinese semiconductor production capacity represented only about 7% of global production. This disparity could be attributed, in part, to a shortage of highly skilled workers integral to the semiconductor manufacturing process. Other significant issues include limitations in the development of essential software tools for semiconductor design, as the production of next-generation semiconductors necessitates the utilization of Electronic Design Automation Software (EDA Software). Some of the semiconductors that require such software include chipsets for smartphones, memory chips (DRAM/NAND), processor chips, and CPU/GPU (graphics cards) for servers and computers.

Given the aforementioned constraints related to labor and technological capabilities in the manufacturing process, the Chinese government has taken proactive steps by providing subsidies for semiconductor manufacturers and give priority to research and development in advanced semiconductor production within the country, with the aim of reducing dependency on imported technology from the US and the EU. Currently, Chinese semiconductor production can satisfy 50% of domestic demand. In light of these limitations, the Chinese government has set an ambitious target for local semiconductor production, with the objective of satisfying 70% of domestic demand by the year 2025. To work towards achieving these objectives, China has established a dedicated to funding semiconductor. The initial phase of this fund was launched in 2021 with an investment value of USD 4.33 billion. Currently, China is planning to actively expand its investments in the second phase of the semiconductor fund by approximately USD 4.37 billion.

Where does Thailand stand in the global semiconductor supply chain?

The shifting dynamics of the global manufacturing supply chain, influenced by geopolitical conflicts, have attracted semiconductor production facility relocations to Thailand. This, in turn, has spurred increased investments in Thailand's semiconductor manufacturing industry. As the tech war unfolded, the United States reduced its imports of semiconductor-related products from China and began to place greater reliance on imports from ASEAN countries, which currently accounted for approximately 42% of its total import share. Thailand has also benefited from this evolving trend, as indicated by the growth in Thai chip-related exports to the United States, which closely correlated with the US semiconductor investment growth outlook (Figure 8). With sustained growth in chip demand, both globally and domestically, especially within the electric vehicle and electronics sectors, coupled with concerns about potential future supply chain disruptions, numerous manufacturers are actively considering shifting their production away from China. Instead, they are looking to friendshore, with a specific focus on ASEAN countries, including Thailand.

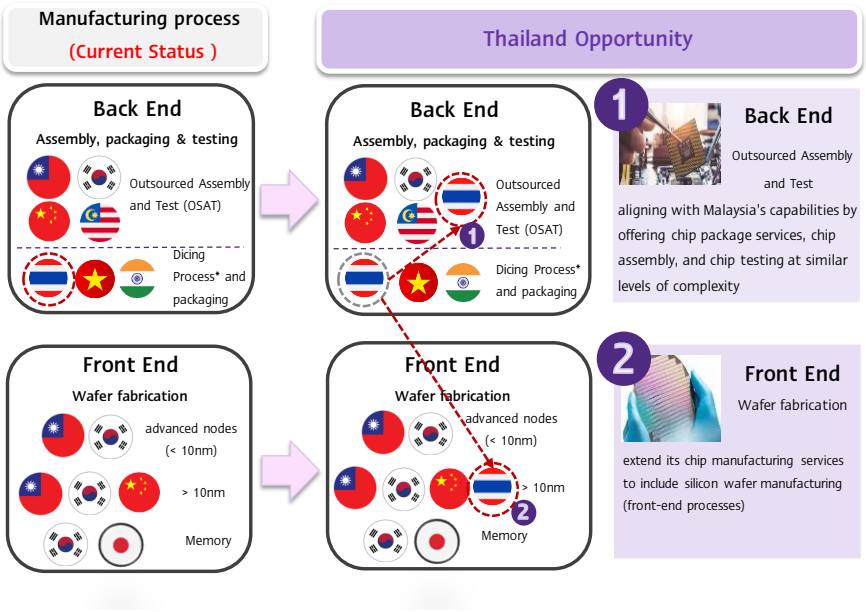
Figure 8: Thai exports of chip-related electronic components to the US continued to grow steadily, reflecting a close correlation with the US' semiconductor industry investment trend.



Source: SCB EIC analysis based on data from the Ministry of Commerce

SCB EIC anticipates a promising future for the Thai semiconductor industry, foreseeing its transformation into a front-end process and higher complexity back-end semiconductor manufacturer. Such potential is substantiated by the influx of foreign investments into Thailand and the supportive measures provided by the BOI. Presently, foreign companies dominate the Thai semiconductor landscape, constituting around 70% of the industry. According to BOI statistics, such foreign companies concentrate their efforts on chip package services, dicing processes, and chip assembly. Prominent among these investors are companies from various countries, including the US (Micron/Maxim), the Netherlands (NXP), Japan (Sony/Toshiba), South Korea (KEC), and Singapore (UTAC). Their primary focus has been on the back-end process of the semiconductor manufacturing supply chain, as imports of upstream raw materials and technology are still required. Nevertheless, Thailand's semiconductor manufacturing capabilities are on par with those of Vietnam and India (Figure 9). More importantly, some semiconductor companies in Thailand that initially specialized in chip package services, such as Sony, Toshiba, and KEC, have begun expanding their investments in Thailand towards upstream processes.

Figure 9: Thailand's potential opportunities in the global semiconductor value chain.



Source: SCB EIC analysis based on data from SIA, Bloomberg, IHS Markit, and Asia.Nikkei.

However, SCB EIC believes that Thailand possesses the potential to further elevate its semiconductor industry and ascend in the manufacturing supply chain. Growth opportunities include aligning with Malaysia's capabilities by offering chip package services, chip assembly, and chip testing (back-end processes) at similar levels of complexity. Furthermore, Thailand could potentially extend its chip manufacturing services to include silicon wafer manufacturing (front-end processes), thereby positioning itself further upstream in the supply chain. This strategic move could potentially put Thailand on par with China's chip production capabilities, particularly for semiconductors exceeding 10 nanometers. Thailand currently enjoys a competitive edge over ASEAN counterparts due to its long established role as a hub for assembling vital electronic components highly sought after in the global market. These components include integrated circuit (IC), printed circuit boards (PCB), and semiconductors equipment and parts. Moreover, Thailand boasts a well-developed public infrastructure. SCB EIC envisions Thailand enhancing its existing chip package services by increasing the complexity of chip assembly services, mirroring Malaysia's achievements. Upon close examination of the Malaysian government's support for its local chip industry, it becomes evident that Malaysia's ascent in the global semiconductor supply chain began with investor recognition of its status in the electronics manufacturing supply chain. This foundation was built on readiness of infrastructure, a highly skilled workforce, expert engineers, and a readiness for related software development. These fundamental strengths served as a springboard for Malaysia's chip manufacturing supply chain development. Currently, Malaysia has successfully attracted substantial foreign investments from companies, such as Intel (USA), AT&S (Austria), and ASE (Taiwan), firmly integrating itself into the global chip production supply chain. Meanwhile, Thailand enjoys similar advantages, as it has consistently strengthened its electronic components manufacturing industry that is closely connected to the chip production supply chain, garnering recognition from major investors. In addition, the Thai government also offers attractive

policies and incentives, including BOI's enhanced benefits for semiconductor manufacturing, covering investments spanning the entire supply chain, from wafer production to semiconductor and parts. Other attractive offers are in terms of benefits from relocating production facilities within the world's electronics production supply chain to Thailand. As such, Thailand has effectively attracted more foreign investments to its chip industry, encompassing front-end chip production (Japan/South Korea), back-end chip package services (USA), and industries closely tied to chip production (Taiwan/China), such as integrated circuit (IC) and printed circuit board (PCB) production. The latest data from BOI revealed that during the first half of 2023, the majority of approved projects in Thailand's electrical appliances and electronics sector stemmed from FDIs, amassing nearly THB 107,688 million in project value. Of these approved projects, 5 were associated with the production or testing of semiconductor equipment and integrated circuits, totaling an investment value of THB 12,957 million, approximately 12% of the total investments in the electrical appliances and electronics sector.

On the other hand, a group of Thai chip exporters may face challenges due to a decline in orders. Nonetheless, prevailing investment trends and the evolving landscape of Thailand's semiconductor industry, it is plausible that Thailand will play a more prominent role in China's production supply chain in the foreseeable future. The ongoing conflict between China and the United States has inevitably impacted a group of manufacturers of semiconductor equipment and parts that rely on exports to the Chinese market from a decline in orders. However, SCB EIC views that semiconductor investments and the strategic trajectory of Thailand's domestic semiconductor industry are undergoing significant developments. Consequently, Thailand may find itself more deeply integrated into China's chip production supply chain in the periods ahead. This view stems from China's high demand for semiconductor-related products. Furthermore, China's semiconductor production capacity remains inadequate to satisfy domestic needs, particularly in the electric vehicle sector, which continues to grow significantly.

In the long run, SCB EIC views that the thriving investments in Thailand's semiconductor industry will yield substantial job creation and stimulate the creation of a novel production supply chain, substantially bolstering domestic market support. These expanding investments in Thailand's semiconductor sector will align with the escalating global demand for semiconductors, thereby boosting the growth of Thailand's semiconductor exports. Moreover, these investments will foster the emergence of a new production supply chain, designed to cater to a myriad of domestic industries, most notably those reliant on semiconductor and parts as vital elements. Particularly, the electric vehicle and electronics industries. Additionally, heightened investments will have a favorable effect on the labor market, significantly increasing employment opportunities within the country. Highly skilled professionals should benefit the most, while the investments will also bring in knowledge transfers related to cutting-edge technologies. Likewise, BOI anticipates that Foreign Direct Investment (FDI) projects approved by BOI within the electrical appliances and electronics sector during 1H/2023 will create

approximately 23,353 jobs in Thailand in the coming periods. This represents a staggering 44% of Thai workers hired through approved FDI projects, underscoring the robust employment potential stemming from the growing semiconductor industry.

Nonetheless, Thailand's semiconductor industry faces hurdles associated with technological constraints, primarily stemming from the relatively high costs of investment. Presently, Thailand does not possess proprietary production technologies akin to those of the US or EU, nor does it function as an original equipment manufacturer like Taiwan. Consequently, Thailand's semiconductor manufacturing sector remains primarily concentrated in the mid and downstream segments, constrained by limited production capability. Furthermore, advancements in the semiconductor industry require substantial investments in cutting-edge manufacturing machineries and technological infrastructure. Apart from technology constraints, Thailand also encounters with challenges arising from the imbalance in the domestic labor market as the semiconductor manufacturing sector demands a more substantial workforce of skilled engineers and laborers compared to other industries.

Therefore, Thai companies aspiring to be part of the evolving semiconductor production supply chain must adapt and keep up-to-date via these 4 advised strategies: **1) Establishing collaborations with government and private sector** to fortify strength within the semiconductor manufacturing industry. **2) Actively pursuing new partners and co-investors by capitalizing on the advantages of relocating production bases**, thus enabling progression from midstream and downstream segments of the semiconductor manufacturing to the upstream ones. **3) Strengthening domestic semiconductor production capabilities** by focusing more on research and development, in addition to learning how the world's main semiconductor producers strengthen their production capabilities. An initial step could start from the development of low-tech semiconductors to gain a foothold in the world market before venturing into advanced semiconductors, primarily due to lower initial investment requirements; and **4) Promoting workforce skills development, both hard and soft skills**. For hard skills, the emphasis should be on upskilling and reskilling workers within the industry to align with evolving market demands, particularly vital in the digital technology sector. Simultaneously, soft skills development should target on enhancing interpersonal skills and teamwork, catering to the demands of the digital age. These measures not only support the semiconductor industry's future adaptations but also foster sustainable growth in the long run.

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