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# Semiconductors: Navigating Supply Chain Resilience and Trade

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## Introduction

The semiconductor industry is a core pillar of the global technological landscape, facilitating the functioning of countless electronic devices that have become integral to modern life. The key components, commonly referred to as integrated circuits or chips, serve as the foundation for a diverse array of applications from handphones, computers, healthcare technology, military defence technology, AI components and advanced wireless networks. With over 100 billion devices incorporating semiconductors, their ubiquity underscores their pivotal significance in driving global value chains and technological advancement (SIA, 2023).

The semiconductor supply chain functions with a highly complex web. The supply chain starts off with research and development, where new techniques and equipment are pioneered to produce ever smaller chips and more densely packed circuits. The second element of the supply chain is the design component and then mass produced in special facilities for fabrication. These activities comprise the front end of the supply chain. The back-end of the supply chain involves specialised assembly, packaging and testing of the chips before they are sent for assembly on circuit boards and in the device they are intended for (Varas et al., 2021). The highly specialised processes in the supply chain are also supported by complex machinery which in themselves have a sprawling network of suppliers, and many thousands of components. The extreme ultraviolet lithography (EUV) machine that can etch designs on the smallest chips is made up of "100,000 parts, 3,000 cables, 40,000 bolts, and two kilometres of hosing" (Thompson, 2021). More critically, it can only be manufactured by one company, ASML in Netherlands. **The semiconductor supply chain involves a high level of complexity and yet is critically dependent on specific nodes or chokepoints for production.**

When the pandemic caused global disruptions to chip supply, policymakers realised that they had not kept up with the risks associated with this complex and globalised network. The supply chain is also facing challenges from the rising trade tensions between the US and China. These two factors have prompted a re-evaluation of supply chains from a risk-based and geopolitical perspective. Beyond simply facilitating private sector led globalisation, bureaucrats and political leaders must now consider how to manage the risks arising from critical chokepoints in supply chains or how they could be weaponised by geopolitical rivals (Farrell and Newman).

This policy brief presents a summary of the current thinking on supply chain resilience of semiconductors. What are the key challenges to supply chain resilience, with a particular focus on Taiwan's and Malaysia's respective positions as critical node and key supporting player in the supply chain?

The brief begins with a summary of modern semiconductor supply chains, as well as Taiwan and Malaysia's respective positions within them. We proceed to analyse contemporary literature on the idea of supply chain resilience, as well as current semiconductor cooperation between Taiwan and Malaysia. We then discuss the challenges that come with building supply chain resilience, namely the prohibitively large upfront investments needed, potentially high costs that would be passed on to end-consumers and acquiring the necessary skilled labour. As well, we note that the ongoing decoupling between the US and China may prove awkward for smaller countries seeking to expand their presence within the semiconductor supply chain such as Malaysia, who may eventually be forced to choose either side and lose access to the other's markets. Finally, we end our paper by considering how trade agreements may help facilitate supply chain resilience, and particularly the benefits that Taiwan may accrue through membership of the Comprehensive and Progressive Trans-Pacific Partnership (CPTPP). Even if Taiwan proves unable to join the CTPP due to geopolitical reasons, our brief argues that Taiwan may achieve the same goal by expanding bilateral and multilateral cooperation with ASEAN Member States.

The brief does not set out to provide a conclusive finding on whether trade agreements would boost supply chain resilience, but to trace the nascent discussion on how they may be interrelated, pointing to future lines of thinking and study.

## Understanding the semiconductor supply chain

Semiconductors (also known as integrated circuits or computer chips) have emerged as one of the most critical sectors of the global economy, rivalling the oil and gas sector in terms of its sheer geopolitical importance. Global annual sales of semiconductors are significant, with annual sales increasing 3.3% in 2022 to reach more than half a trillion dollars (Thadani and Allen, 2023). Future prospects are also encouraging, with one estimate projecting the global semiconductor sector to reach a valuation of USD 1.31 trillion by 2032 at a CAGR of 8.8% from USD 625.2 billion in 2023 (Market.US, 2024). As of now, the three largest semiconductor corporations in the world - dubbed The Big Three - are Taiwan Semiconductor Manufacturing Company (TSMC), South Korea's Samsung, and the United States' Intel (Taipei Representative Office in Singapore, 2023).

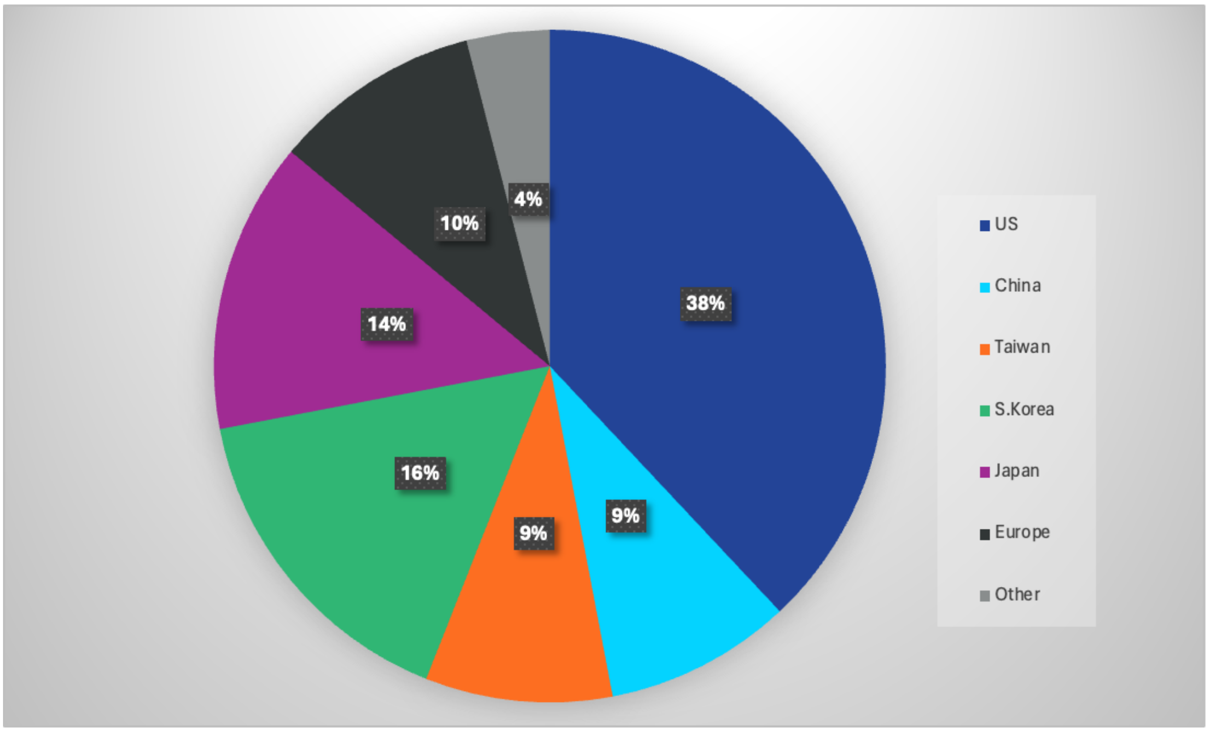
Beyond immediate sales however, the semiconductor industry serves as an irreplaceable enabler of tens of trillions of dollars of annual economic activity worldwide. Semiconductors serve as crucial components of a wide range of goods and services, including data centres, laptops, mobile phones, automobiles, washing machines, light bulbs, weapons guidance systems, and the electrical grid infrastructure. Many key sectors in the global economy depend upon the ready supply of semiconductors. In every modern automobile, for example, there are anywhere between 1,000 to 3,500 semiconductors. Similarly, key aspects of the digital economy including 5G and Internet of Things (IoT) infrastructure are reliant on the availability of cutting-edge microprocessors which only a handful of firms have the capacity to manufacture (Thadani and Allen, 2023, Arcuri and Lu, 2022).

The semiconductor supply chain forms a significant contribution to GDP in many economies, although wafer fabrication (the actual manufacturing of the chips) only takes place in a handful of countries, with production mostly concentrated in Taiwan. Although semiconductors contribute merely 0.3 percent to the overall GDP of the United States, their significance extends beyond this seemingly modest figure. These electronic components play a pivotal role as a production input, influencing approximately 12 percent of the U.S. GDP. This underscores the substantial second-order impact of semiconductors on diverse sectors of the American economy (Thadani and Allen, 2023).

Furthermore, this impact is not confined to the US alone. When we look at the other major nations for semiconductor production, similar significance to national GDP arises. The semiconductor sector makes up some 15% of Taiwan's GDP, with American tech firms including Apple, Amazon, Google, Nvidia, and Qualcomm reliant on Taiwan-based contract manufacturers for nearly 90% of their chips (Arcuri and Lu, 2022). In Malaysia, the E&E sector contributes to 7% of GDP where 65.2% of this is from the semiconductor industry (MATRADE, 2023).

Six major regions have a significant participation in the total global output of the semiconductor industry (see Figure 1), with each region specialising in different activities of the value chain. In 2019, the United States alone comprised 38% of the total value added of the global semiconductor supply chain. Although Taiwan has the largest market share of chip fabrication, it is largely US-based firms that design and order the chips.

**Figure 1: Participation in the semiconductor value chain by region and overall value, 2019 (%)**




Source: (Varas et al, 2021, p.31)

Compared to most other modern economic sectors, the global supply chains that have developed over the last decade for semiconductors are unique in both their sheer geographical concentration (particularly when it comes to the more high-end operations) as well as their complexity. The various inputs to fabrication of an integrated circuit typically crosses more than 70 international borders before the final product can be delivered to consumers. World class chip producers usually have thousands of suppliers around the world, with some suppliers so niche that only they produce such technological capabilities at specific performance levels. It is largely agreed that no single country is currently able to achieve end-to-end independence in semiconductor production, meaning at present countries must continue engaging with each other to ensure continued access to semiconductors (Accenture, 2022).

From a bird's eye perspective, the average supply chain for semiconductors can be broken down into research and development, design, fabrication, and assembly, testing and packaging. Firms that only design chips are known as fabless firms and largely concentrated in the US, while firms that only fabricate chips are known as pure-play foundries, such as TSMC in Taiwan. There are few vertically integrated firms that retain both capabilities, the main exception being Intel (Varas et al, 2023).

| Table 1: Semiconductor supply chain | | |
|---|---|---|
| **Stage** | **Description** | **Estimated Value Add** |
| Research and development | The research and development stage leads all other sectors of the supply chain. It includes pre-competitive, exploratory research on foundational technologies and competitive research directly advancing the leading edge of semiconductor technology. | 15% to 20% (of total industry R&D) |
| Design | The actual manufacturing process begins at the design stage, where the blueprint of the chip is sketched out to optimise for certain parameters (i.e. cost, power consumption, capacity etc) based on the needs of the chip in question.<br><br>While chip designs were once drawn on paper, highly specialised software called **electronic design automation (EDA)** is often used now given the complexity of modern chips.<br><br>Certain portions of a chip's design are built using reusable pieces of intellectual property (IP), called **core IP**, that firms licence from the IP owners.<br><br>The United States leads in chip design, with US firms controlling more than half of the 2019 market share in core IP. US companies are also the exclusive providers of EDA with the requisite capabilities required to design cutting-edge | 50% |

| | | |
|---|---|---|
| | chips. | |
| Fabrication | Fabrication refers to turning the designs into actual chips. It requires several inputs, including raw and manufactured materials (silicon wafers, photomasks, photoresists, and chemicals) as well as **semiconductor manufacturing equipment (SME)**. SME can include wafer fabrication on the front end as well as semiconductor assembly, test, and packaging equipment for back-end fabrication.<br><br>Much of chip wafer fabrication currently takes place in the Indo-Pacific. In 2022, South Korea ranked first in wafer production capacity at 22%, while Taiwan ranked second at 21%. China ranked third at 18% of the world's capacity (including domestic and foreign-invested companies in China), followed by Japan at 15% and the United States at 10%.<br><br>When it comes to global SME market share, US and Japanese firms dominate. US firms alone occupy more than 40% of global SME market share, followed by Japanese companies at 29%. Together with the Netherlands, the three countries dominate the supply of SME. | 24% |
| Assembly, testing, and packaging | Assembly, testing, and packaging (ATP) refers to the back-end of the semiconductor supply chain. It is generally more labour intensive compared to any other part of the supply chain. | 6% |

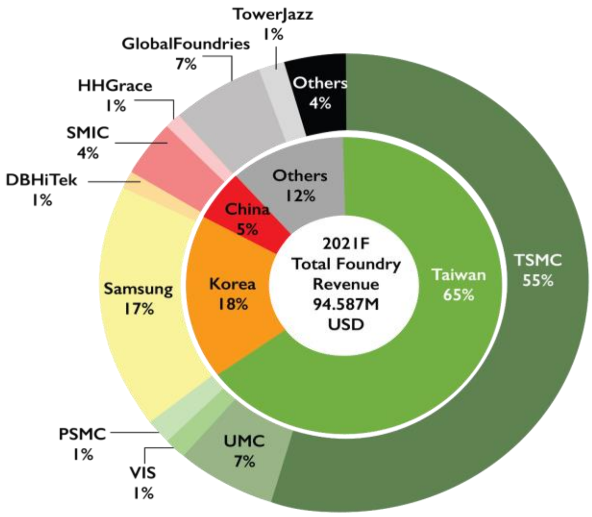
| | | |
|---|---|---|
| | The vast majority of ATP facilities exist in the Indo-Pacific, with a heavy concentration of OSAT providers in Taiwan, China, and Southeast Asia (particularly in Singapore, Malaysia, Vietnam, and the Philippines). | |

Source: Authors' notes compiled from various sources, including Thadani and Allen, 2023; Khan, Mann, and Peterson, 2021; Varas et. al, 2021)

## Taiwan

Over the years, analysts have pointed to the outsized role of Taiwan in the global semiconductor supply chain, namely in the foundry market. This refers to the outsourcing of semiconductor manufacturing. Taiwanese foundry firm Taiwan Semiconductor Manufacturing Co. (TSMC) in particular has emerged as an indispensable node to the global supply of chips. By total foundry market share, in 2021 TSMC recorded a market share of 55%, while South Korea's Samsung followed with 17% (see Figure 2) (TrendForce, 2021). By one estimate, TSMC provides 35% of the world's automotive microcontrollers and 70% of the world's smartphone chipsets. The company also dominates in the production of chips for high-end graphics processing units in PCs and servers (Vest, Kratz, and Goujon, 2022).

**Figure 2: Market Share of Foundry Firms, 2021**




Source: [Trendforce](), 2021

Qualitatively, Taiwan and South Korea have emerged as leaders in the foundry business. TSMC and Samsung are currently the only two businesses in the world that can manufacture the most advanced 5-nanometer semiconductors. Estimates from the Semiconductor Industry Association saw that Taiwan holds a strong 92% of the world's most advanced chips production of below 10 nm (2021). TSMC is also among the highest spending semiconductor companies in the world, with the company's capital expenditure (capex) estimated at US$32 billion in 2023, representing 23% of total semiconductor industry capital spending that year. Indeed, the combined expenditure of TSMC and Samsung (which also stood at US$32 billion) stood at 46% of total industry expenditure (Taipei Representative Office in Singapore, 2023).

**Malaysia**

Malaysia also plays a pivotal role in the global semiconductor supply chain, having been a major exporter of semiconductor devices in recent years. According to data by the Malaysian Productivity Corporation (2023), semiconductor exports summed up to RM 593 billion in 2022. Malaysia was also the world's eleventh largest importer of semiconductor devices with USD 3.83 billion worth of imports, mainly from China, Singapore, US, Japan and Germany (OEC, 2022). Globally, 7% of semiconductor trade flows through Malaysia (MATRADE, 2023).

Malaysia's position within the global semiconductor supply chain is mostly focused on back-end operations, with a key focus in assembling, testing and packaging (ATP). It is estimated that some 13% global backend operations are currently supported by Malaysia (Malaysian Productivity Corporation, 2023). However, there is much effort by both industry players and the government to push the Malaysian semiconductor industry higher up the value chain towards integrated circuit (IC) designs and wafer fabrication. Currently, Oppstar Technology Sdn Bhd which focuses on custom IC designs is one of the few Malaysian made front-end manufacturers (MIDA, 2020).

Another Malaysian-made front-end manufacturer is IC Microsystems Sdn Bhd (ICMIC) which is a fabless design company. Although currently their focus is on growing the agritech industry, ICMIC is well rooted in curating designs for phone ICs, semiconductor processes, and electronics applications. Moving forward, Malaysia sees more potential in attracting IC design companies as well as wafer fabrication companies to invest in Malaysia. According to the National Industrial Master Plan (NIMP), Malaysia aims to increase collaboration with other ASEAN countries in order to combine talent on semiconductor front-end production and push the industry higher up the semiconductor value chain. The table below highlights the top four companies based in Malaysia that are involved in front-end manufacturing, both Malaysian and foreign.

**Table 2: Front-end semiconductor firms based in Malaysia**

| Company | Position in Malaysia | Origin |
|---|---|---|
| Osram[a] | Osram Semiconductors has been operating a production facility in Penang since 1978, where it functions as an R&D centre for LED assembly, chip production for LEDs, and package assembly centre for both LED and IR components. Additionally, since 2017, the company has extended its production capabilities to Kulim, focusing on chip production for LEDs and package assembly specifically for LED products.<br><br>Components in Supply Chain:<br>- Wafer Fabrication<br>- IC Designs<br>- ATE services | Germany |
| IC Microsystems | ICMIC engages in IC design, offering a range of fabless products. These include solutions for smart precision farming and IoT applications, data converters, phone ICs, phone board modules, and RF products.<br><br>Components in Supply Chain<br>- IC Designs<br>- Fabless Production | Malaysia |
| Oppstar | Oppstar specialises in providing custom IC design services, possesses expertise in core IP design, and offers full turnkey ASIC solutions. Their services encompass architecture consulting, RTL design, design verification (DV), design for test (DFT), analog and mixed-signal design, physical design, FPGA emulation and prototyping, post-silicon validation, and turnkey solutions. Oppstar's chip designs range from 20 nm to 5 nm process node technology.<br><br>Components in Supply Chain<br>- IC Designs<br>- Full Turnkey ASIC Designs | Malaysia |
| Xfab | The Malaysian establishment operates with processes that range from 350 nm to 130 nm process node technologies. Xfab Malaysia is also involved in CMOS logic and mixed-signal technologies, as well as 250 nm embedded flash, CMOS image sensor, and CCD capabilities. Additionally, they handle 350 nm and 180 nm high-voltage processes, along with 250 nm, 180 nm, and 130 nm flash technologies. Their overall capacity amounts to 30,000 eight-inch | Germany |

| | | |
|---|---|---|
| | equivalent wafers per month.<br><br>Components in Supply Chain<br>- Wafer Fabrication | |

Source: Collated from multiple sources by author.
a: source from Invest Penang

## Supply chain resilience

### The shift towards resilience

Prior to the COVID-19 pandemic in 2020, global supply chains had been planned with efficiency in mind. The overriding impetus of supply chain professionals had been to drive down waste and costs, at the expense of limited flexibility when responding to sudden changes to supply, demand, and logistics. The subsequent pandemic, the supply chain bottlenecks that followed, as well as the impact of the conflicts in Ukraine and the Middle East, have almost entirely upended our traditional understanding of supply chains. As pundits have noted, we have now shifted from 'Just in Time' to 'Just in Case' (Diaz, 2021).

Nowhere is this need for balancing efficiency and resilience more pertinent than in the supply chain for semiconductors, given the sheer importance of semiconductors in powering the larger digital economy.

### The 2021 chip shortage and 2011 Japan earthquake as case studies

The outsized impact of sudden disruptions in semiconductor supply chains can best be demonstrated during the chip shortage of 2021, which was attributed to the demand for chips exceeding supply capacity. The chip shortages would have a wider impact on the global economy. Automakers experienced production halts, with analysis by the U.S. Department of Commerce finding that the chip shortage shaved an estimated US$240 billion off U.S. GDP in 2021. The auto industry alone produced 7.7 million fewer cars in 2021 due to lack of chips. Vehicle production in Europe was impacted too - German production dropped 20% while Italian production fell over 25% (Dimerco, 2023, Thadani & Allen, 2023, Attinasi et. al., 2021, Vest, Kratz, and Goujon, 2022).

The 2021 chip shortage would also cause delays in electronics product launches around the world, while also fuelling price inflation around the world for consumers. Meanwhile, export-oriented economies in the Asia-Pacific that depend heavily on the export of electronics, such as South Korea, saw their overall growth impacted (Dimerco, 2023).

Another large-scale disruption to global semiconductor supply chains was the 2011 earthquake and tsunami in Japan. By one count, 25% of the global production of silicon wafers and 75% of the global supply of hydrogen peroxide (a key element used to cleanse semiconductors substrates) was affected by the disaster. Several fabrication facilities were also shut down for several months (Varas et al., 2021).

Ultimately, both the 2011 earthquake in Japan and the 2021 global chip shortage caused significant albeit temporary damage to the global economy. In comparison, we can expect a substantially more catastrophic outcome from a larger-scale and more prolonged disruption, such as a military conflict between Taiwan and China. According to a December 2022 study by consultancy group Rhodium Group, the impact of a possible blockade of Taiwan by China on semiconductor supply chains could see as much as US$1.6 trillion in annual losses for industries that are directly or indirectly dependent on Taiwanese chips. The study also found that the global economy would face significant second-order impacts that would likely add trillions more in economic damage. Many industries depend on the availability of goods and equipment containing Taiwanese chips, including e-commerce, logistics, ride-hailing, entertainment, and other industries that collectively employ tens of millions of people around the world. Spare parts and components for critical public infrastructure, such as telecommunications and medical devices, could also become disrupted (Vest, Kratz, and Goujon, 2022).

## A shift towards interventionist policies

Such was the impact of the 2021 chip shortages that the U.S. administration in the same year recognised the need for a comprehensive and policy-centric approach in order to ensure "resilient, diverse and secure" supply chains. The Executive Order on America's Supply Chains called for 100-day reviews of all the gaps, current challenges, and status of supply chains from various industries, with semiconductors the first-mentioned sector on the list. Given that the semiconductor industry plays a critical role across various economic sectors in the US, the findings noted the need to rebuild domestic production capabilities, especially given that semiconductor production is only six to nine percent of global chip production, while Taiwan in comparison comprises more than 60% of overall production and 92% of the production for leading edge chips.

It is within this context that policy-thinking has moved away from the traditional laissez-faire approach that built complex and efficient supply chains albeit with critical choke points towards a more interventionist stance that actively supports supply chain resilience. As the pandemic abated and US-China trade tensions once again came to the forefront, the policy discourse on resilience began focusing on the wider geopolitical concerns about the complex relationship between economic logic and national security. Many countries around the world are seeking to re-shore or onshore semiconductor fabrication in order to prevent future chip disruptions.

**Malaysia's role in Taiwan's supply chain resilience efforts**

Experts have noted that the semiconductor sector provides a major avenue for furthering the Taiwanese-Malaysia economic relationship, which is already quite substantial. In 2023, Taiwan stood as Malaysia's fifth-largest trading partner, while Malaysia stood as Taiwan's eighth-largest. Trade in 2023 reached a historical high of US$36.6 billion (RM172.4 billion), a 36% increase compared with 2022. Taiwan represented Malaysia's eighth largest investor in 2022, investing a total of US$14 billion by year-end (MIDA, 2023).

Malaysia has already been identified as holding substantial potential when it comes to Taiwanese semiconductor investments, with more than 50 Taiwanese multinational semiconductor enterprises currently operating in the country. The Malaysian government has identified the semiconductor sector as a key part of its industrial plan, with ambitions to move the industry further up the value chain towards more front-end activities such as wafer fabrication and IC design (Ruehl, 2024).

Despite this, most of the recent semiconductor-related investments into the country remains in back-end operations. Recently, authorities have approved a US$7 billion facility at the Kulim Industrial Park in Kedah owned by Germany's Infineon. The site is expected to become the world's largest production site for silicon carbide chips, a type of power semiconductor used in electric cars, wind turbines, and other heavy applications, as well as consumer electronics. Meanwhile, at Bayan Lepas in neighbouring Penang, Intel is constructing its biggest site yet for advanced 3D chip packaging. Many of these firms have been expanding operations in Malaysia in response to the ongoing-Sino-US chip war (Ruehl, 2024, Collins, 2023).

Analysts argue that Malaysia likewise provides a welcome production site for Taiwanese chipmaking firms looking to diversify their operations away from China. As noted in an op-ed for The Edge published in December 2022 by Lee Chee Leong and Lin Kai Min, the future trend of Taiwanese investments 'will be based on a two-pronged approach that serves to capture both China and the global markets separately. By diversifying their know-how, capital, and technologies into Southeast Asian countries, Taiwanese investors are circumventing the supply chain disruptions emanating from acute geopolitical rivalry and the fluctuating situations on China's domestic front' (Lee and Lin, 2022). Given Malaysia's relative political stability, lack of risks of major natural disasters such as earthquakes and typhoons, convenient geographical location, and English-language skills, experts have argued that Malaysia provides an ideal investment destination for Taiwanese firms.

## Challenges towards building resilience

### 1. High upfront investments

Many major economies around the world are actively seeking to address supply chain vulnerabilities in semiconductors through policies of re-shoring[1]. However, most analysts argue that this would require massive upfront investments on the part of semiconductor firms.

At present, different regions of the world are focused primarily on different activities within the semiconductor supply chain (i.e. the United States focusing on design, East Asia focusing on fabrication, the US and Japan specialising in manufacturing equipment, etc) (Varas et al., 2021). This regional division of tasks has been driven by comparative advantage developed over the past decades of the industry's history. When it comes to chip fabrication, the costs of fabrication increase with technological advancements, and is prohibitive to all but the largest companies. The high level of specialisation and interdependency in the supply chain is such that it is generally agreed that the investment outlays needed for complete self-sufficiency is thought to be non-feasible.

According to one 2021 report, attempting to achieve self-sufficiency in every layer of the semiconductor supply chain would require US$900 billion to US$1,225 billion in upfront investment to cover each region's 2019 consumption levels. Furthermore, any further growth in domestic consumption would require further investments in additional capacity for each region. The report estimated that the global semiconductor industry would incur US$45 to US$125 billion in incremental recurrent annual operational costs (Varas et al., 2021).

According to another estimate, if the global chip industry invests US$100billion annually in capital, then China would have to commit the same for many years, committing over a trillion dollars to catch up (Miller, p.323). Re-shoring chip manufacturing to the US, which had hollowed out its manufacturing capacity over the years, would be not much less prohibitive in terms of costs. It should be noted that in these scenarios, semiconductor firms would be required to make these huge upfront investments while also possibly suffering from the loss of access to major markets due to security-related reasons, thereby leading to losses of revenue (Varas et al., 2021). With chip supply becoming an issue of national security as well as an economic opportunity, government incentives in this area have developed rapidly in the past few years. Even with government incentives, the cost of building in redundancies or eliminating chokepoints in the supply chain may be mitigated but not fully alleviated.

[1] Re-shoring happens when a business that had moved operations "offshore" to a foreign country decides to bring back operations to their home country.

Below is a table of different countries' specific strategies for reshoring or onshoring semiconductor fabrication within their respective territories, as well as the incentives being offered to kickstart the process:

**Table 3: Government strategies and incentives for promoting semiconductor production reshoring or onshoring**

| **Country** | **Law / Policy** | **Incentives** | **Value (where stated)** |
|---|---|---|---|
| United States | CHIPS and Science Act | Scientific R&D and Commercialization (USD 200 billion)<br><br>Semiconductor R&D and workforce development (USD 52.7 billion)<br><br>25% investment tax credit for qualifying facilities and equipment (USD 24 billion) | USD 280 billion between 2022 - 2026 |
| India | Semicon India | Match package up to 50% of cost of setting up new semiconductor and display fabs (USD 10 billion)<br><br>Incentives for electronics and IT manufacturing (USD7.5 billion)<br><br>Incentives for "allied sectors" such as EVs, solar PV modules, and telecom products (USD 13 billion) | USD 30 billion |
| Japan | Fiscal 2023 Supplementary Budget allocation | Incentives for Rapidus to manufacture 2nm semiconductors (USD 4.37 billion)<br><br>TSMC Plant construction and related projects (USD 4.27 billion)<br><br>Ensure a stable supply of semiconductors and manufacturing equipment (USD 3.89 billion) | USD 12 billion |
| Taiwan | Statute for Industrial | 25% tax deduction on R&D expenses | |

| | | | |
|---|---|---|---|
| | Innovation | 5% tax deduction on expenditure for new machinery used in advanced processes | |
| South Korea | K-Chips Act | Increase in base tax credits for eligible investments in facilities of national strategic importance (25% for SMEs, 15% for large companies)<br><br>Additional 10% tax credit for ongoing incremental investment in national strategic technologies | - |
| China | Measures aimed at attaining semiconductor self-sufficiency | Subsidies to 190 domestic chip firms, namely SMIC and Sanan Optoelectronics (USD 1.75 billion)<br><br>Tax credits on R&D expenditure in chip technology of up to 220% of taxable income if they qualify for patents<br><br>Up to 10 years of corporate tax exemption for advanced (28 nm) node fabrication lines and exemptions on import duties for integrated circuit manufacturers to import materials and equipment | - |

Source: Notes compiled from various sources.

## 2. Rising costs for consumers

As countries seek more resilience in supply chains, analysts warn that semiconductor firms may have to pass on at least a portion of their incremental costs to device makers in the form of higher prices for semiconductors. One study estimated that a hypothetical shift towards fully self-sufficient supply chains could lead to an average increase of between 35% to 65% in the price of semiconductors. Even for strategies for resilience that aim to create only a portion of additional or redundant capacity, there would arguably be some cost increases that cannot be completely absorbed by the industry (Varas et al., 2021).

Disengaging from certain markets as part of derisking strategies will inevitably lead to loss of cost-effective production. In the case of the United States, for example, a push towards resilient supply chains may require losing access to assembly, testing and packaging (ATP) facilities in China (out of 484 ATP facilities counted in 2021, 134, or 28%, were in China)

(Thadani and Allen, 2023). It may also require losing access to several strategic materials used in semiconductor production that China currently dominates in, such as rare earths. By one count, China leads in the extraction of 9 of the 17 critical raw-material inputs and in the refining of 14 of them (Varas et al, 2021).

As such, the end result would ultimately be higher prices for electronic devices for consumers, thereby ending a decades-long trend of electronic devices becoming more affordable over time. There is also a risk that siloed and protected domestic industries would lose out in efficiency and ability to innovate.

While the provision of government incentives may help alleviate the need for semiconductor manufacturers to pass on their incremental costs to end-consumers, depending on the specific country it may require large amounts of incentives nevertheless to cushion consumers from the impact.

### 3. Lack of skilled labour

An acute issue facing many countries including Malaysia in its quest to move up the semiconductor value chain is the lack of skilled labour. It should be noted that wafer fabrication is a very complex, specialised operation that typically takes two to four years to build and put into commercial operation. It also typically requires 3,000 to 6,000 staff to operate, with most being skilled technicians that need to be recruited and trained. In the case of Malaysia, the country currently faces a glaring shortage of engineers. By one count, only 5,000 engineering students graduate annually in Malaysia while the country's electrical and electronics sector alone requires 50,000. Low salaries for engineers, particularly for starting engineers, often sees many Malaysian engineers migrate abroad for better job opportunities.

Supplying the labour expertise needed to move up to the front-end of the chip supply chain may be beyond Malaysia's present capabilities. At present, the semi-skilled workforce comprises the majority of the formal Malaysian workforce, standing at 62.3% in the third quarter of 2022. In the same quarter, the skilled workforce represented 24.9% of the formal workforce, while low-skilled workers only represented 12.8%. While having a large share of semi-skilled workers is not necessarily unusual for an upper-middle income country, it should be noted that this skills breakdown has more or less remained consistent since 2011, suggesting difficulties on the part of Malaysia in developing its skilled labour (DOSM, 2022).

### 4. Geopolitical risks

Much of the push towards more resilient global semiconductor supply chains has been led by geopolitical concerns, namely the so-called Chip War between the US and China. The Chip War arguably began in 2020 when the then-Trump administration began blocking the shipment of high-end semiconductors and semiconductor manufacturing equipment to

Chinese firms. Later in 2022, the Biden administration would continue to tighten said restrictions, including publishing a sweeping set of export controls which included measures to cut China off from certain semiconductor chips made anywhere in the world with US equipment, as well as cutting edge chip making equipment. Japan and the Netherlands would promptly follow suit from the US that same year. The Biden administration's export controls also saw many China-based facilities of foreign wafer fabrication firms cease operations. In response, China would proceed to double down on its goal of tech self-reliance (Reuters, 2023, Thadani & Allen, 2023).

The impetus for the Chip War can be largely attributed to concerns over how asymmetric relationships in semiconductor supply chains could be exploited by rivals through so-called 'weaponised interdependence'. This is a concept that has been pushed by academics Farrell and Newman (2019). For instance, at present ASML Holding N.V. based in the Netherlands is the only supplier in the world of the latest generation photolithography scanner equipment (extreme ultraviolet, or EUV, lithography machines) used for cutting edge chip fabrication.

In 2023, the US was able to leverage upon its relationship with the Netherlands to cut off ASML's cutting edge tech from China, posing a blow for the latter. Although Huawei seems to have produced its own 7nm chips in 2023, it is thought that the current export restrictions will continue to keep China out of the highest technology for chips for many years (Fuller, 2023).

Whether the United States and its partners will extend its tech restrictions to other areas of the semiconductor supply chain remains to be seen. From the perspective of third-party countries aspiring to expand their presence within semiconductor supply chains, such as the case with Malaysia, the fear remains that the ongoing decoupling between the US and China may force them to ultimately choose sides and thereby lose access to the other's markets.

In the case of Malaysia, while the country is currently benefiting from the US-China decoupling insofar as its encouraging firms to move shop to Malaysia, there is a question of whether Malaysia will be eventually forced to choose between the Chinese or American market in the long-run. Since the Trump administration began imposing trade restrictions on Chinese tech (which were maintained and tightened by the subsequent Biden administration), Malaysia has started to see an increase in investments from mainland Chinese companies. By one count, there are now 55 mainland companies operating in Penang in manufacturing (mostly in semiconductors), compared to just 16 before the American crackdown began (Ruehl, 2024).

While most of the Chinese firms investing in Malaysia are still focused on back-end operations, there are fears that should these operations move into more sensitive and higher-value sectors, it may invite more targeted restrictions from the US (Ruehl, 2024). Should American policymakers seek to expand their restrictions on Chinese tech to include products and services made in other countries, this may shut Malaysian companies out of the crucial

American market. Should Sino-US ties continue to deteriorate, Malaysian firms may be forced to choose one side to collaborate with, which would be detrimental to Malaysia's goal of upgrading its own operations. However, given the integrated ecosystem in Malaysia, restrictions would likely equally disrupt US companies that are invested here.

## Trade and Supply Chain Resilience

While many countries and/or regional blocs around the world are actively seeking resilience in semiconductor supply chains by investing in indigenous chip production capabilities, achieving fully self-reliant semiconductor supply chains may prove increasingly challenging if not impossible. This is due to a myriad of challenges posed, including the high upfront investments needed, rising costs passed on to consumers, and acquiring the necessary skills. As well, the ongoing decoupling between the US and China may prove awkward for smaller countries seeking to expand their presence within the semiconductor supply chain such as Malaysia, as they may eventually be forced to choose either side and lose access to the other's markets.

In light of these challenges, countries may find it more prudent to forgo seeking wholesale indigenous self-sufficiency in favour of establishing 'minimum viable capacity' to produce the most critical components and finished products in a time of crisis. Pundits have argued that this presents a more viable and cost-effective strategy for governments to adopt. For instance, a 2021 report jointly written by BCG and SIA argue that the United States has the ability to reshore production of advanced logic chips, which are associated with critical infrastructure applications including aerospace and defence systems, core telecommunications networks, and supercomputers and data centres for essential sectors such as government, energy, transportation, healthcare and financial services (Varas et al., 2021).

### How trade agreements can facilitate supply chain resilience

In the intricate web of global commerce, the interplay between trade dynamics and supply chain resilience has become a focal point of inquiry. With the increasing complexity of international trade relationships, coupled with the imperative need for resilient supply chains, it is important that governments and institutions create a semiconductor ecosystem in which regional partners can collaborate and grow in order to ensure a more resilient network of products (CSIS, 2021).

Trade agreements are a consensus between two or more countries to reduce certain trade restrictions that are present in an economy, and these agreements can range from free trade agreements (FTA), bilateral agreements and multilateral agreements. According to the OECD, a key measure towards resilience in the supply chain is to increase trade between nations.

International cooperation is a recommended means towards easing disruptions caused by border bottlenecks and supply shocks, and it can help reduce trade costs.

The OECD recommends four key pillars to ensure open markets which will ultimately facilitate trade openness. These include predictability and transparency, international agreements, trade facilitation and international regulatory cooperation. These pillars aim to establish markets which follow a rule-based trading system, thereby ensuring a stable movement of the supply chain even during periods of crisis. The pillars also carve a path towards creating smoother border processes with the use of technology to simplify processes for all business units. These pillars also aim to create an environment where communication and information sharing is well coordinated between government and other industry players to ensure smoother movement of the supply chain. Through the lens of the semiconductor supply chain, the OECD's recommendations offer a pathway to foster a resilient supply chain, strengthening regional integration without the need for extensive investments in constructing new semiconductor plants. Furthermore, studies have found that FTAs have increased overall foreign direct investment (FDI) rates in a nation due to decreased tariff rates (Duong et al, 2020).

## Taiwan and the CPTPP

The Comprehensive & Progressive Trans-Pacific Partnership (CPTPP) is a free trade agreement (FTA) between eleven Asia Pacific economies: Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam signed on 8 March 2018. The CPTPP, which covers about 14 percent of global GDP, is the third largest free trade area in the world after the North American Free Trade Agreement (NAFTA) and European Single Market. On the 22 September 2021, Taiwan formally sent in a request to join the CPTPP. However, Taiwan has not yet been ratified into the agreement. Despite this, Taiwan has well established trade relationships with some members of the CPTPP. In 2017, one-fourth of Taiwan's trade was with CPTPP Members. Among these members, Japan, Singapore, and Malaysia ranked among Taiwan's top 10 trading partners. Moreover, around 30.42% of Taiwan's total FDI came from CPTPP Members, while over half (54%) of its outbound investments were likewise directed to them. This data underscores Taiwan's deep integration into the CPTPP value chain, as evidenced by the substantial imports from CPTPP Members (ROC, 2020).There are a few gains that could be present in the case Taiwan’s request to become a member of the CPTPP is fulfilled.

Focusing on the gains to be made for Taiwan’s semiconductor sector, a study found that some of Taiwan’s trading partners already enjoy low tariff rates due to the most favoured nation (MFN) treatment. Japan, who imports 40% of integrated circuits from Taiwan, would not enjoy any more tariff reductions if Taiwan joined the CPTPP because they already enjoy zero tariff rates under Most Favoured Nation (MFN) treatment (Wang, 2022). Despite that, gains are still predicted to be seen because the CPTPP not only promises expanded market access for goods but crucially offers a transparent and stable framework for services and investments. This shift signifies a commitment to openness, enabling Taiwanese businesses, especially those in the burgeoning high-technology sector, to provide services with reduced trade barriers and costs. Indications propose that nations prioritising the establishment of free trade agreements to foster unhindered trade, along with the enhancement of top-notch infrastructure, will possess a competitive edge in attracting high-tech, high-value investors compared to their counterparts (Jayasinghe et al, 2023).

Apart from that, diversification of trading partners also emerges as a compelling driver for Taiwan's CPTPP membership. The disruptive impact of unforeseen measures, such as China's abrupt import bans on Taiwanese agricultural products in 2021, underscores the vulnerabilities associated with overdependence on a single trade partner. By entering CPTPP, Taiwan aims to mitigate such risks by reducing trade barriers among member countries, thereby fostering a more resilient economic environment. The prospect of enhancing trade relationships and reducing potential losses in the face of unilateral restrictions from significant partners underscores the strategic imperative of Taiwan's CPTPP participation.

**In lieu of the CPTPP, focus on bilateral or multilateral cooperation**

While membership of the CPTPP brings myriad benefits for Taiwan, it is also unlikely in the near-to-medium term given geopolitical reasons. It should be noted that Taiwan had submitted its application one week after China made its application, meaning the latter's application will be given precedence. China will most likely insist on joining first, and should it successfully ascend it will most likely exclude Taiwan. Even if China proves amiable to Taiwan joining, China's own accession seems unlikely given several challenges, such as discrepancies between Chinese policy and CPTPP standards in the areas of labour, the environment, state-owned enterprises, and digital commerce (Wiendieck and Stark, 2023).

Even without membership of the CPTPP, experts argue Taiwan can still achieve supply chain resilience through expanding bilateral or multilateral cooperation with individual ASEAN Member States. The potential for further economic cooperation between Taiwan and Southeast Asia is considerable given the converging economic specialities of both parties - Taiwan as a major producer of semiconductors, and many Southeast Asian countries as manufacturers of electronics goods which require chips.

With many ASEAN economies seeking to move their manufacturing into more high-end operations in green tech and the digital economy, Taiwanese-manufactured chips will no doubt play a major role and should be leveraged upon. Establishing chip production in Southeast Asia-based facilities would help facilitate Taiwan's push for supply chain resilience by spreading out its manufacturing across a wider geographical footprint rather than being concentrated in Taiwan alone. In the event of an extreme supply chain disruption such as a Chinese blockade of Taiwan, Taiwanese chips would still be able to be physically delivered to end-consumers based in Southeast Asia, be it Thai automakers or consumer electronics manufacturers in Malaysia and Vietnam. Supply chains would still be able to operate, thereby reducing the number of supply chain chokepoints and promoting greater long-term resilience (Chin, 2023).

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