IDEAS
INSTITUTE FOR DEMOCRACY AND ECONOMIC AFFAIRS

IDEAS Policy Brief

Semiconductors: Navigating Supply Chain Resilience and Trade

Authors: Imran Shamsunahar, Alissa Rode, Sharanyah Nair

Acknowledgements
We would like to thank Sri Murniati Yusuf and Nischal Ranjinath Muniandy for their valuable contributions to the paper

1. Introduction

IDEAS' paper, "Semiconductors: Navigating Supply Chain Resilience and Trade," investigates whether stronger multilateral trade integration can promote supply chain resilience. This is investigated through an evaluation of the critical supply chain in semiconductors as a case study. The paper explores 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 semiconductor supply chain. The paper also provides recent arguments on multidimensional free trade agreements that may help increase supply chain 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.

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, 2019). Supply chains that once functioned on a "just in time" management system, must now integrate resilience into the equation (Diaz, 2021). In 2020, global trade in goods and services fell by 9.6% due to disruptions, prompting a re-evaluation of supply chains from both risk-based and geopolitical perspectives. The COVID-19 pandemic exposed vulnerabilities in global supply chains, which now face threats from rising US-China trade tensions and the impact of the conflict in Ukraine and the Middle East.

2. Understanding the semiconductor supply chain

Semiconductors are crucial to the global technological landscape where the key component, integrated circuits or chips, are present in over 100 billion devices, powering an array of technologies. Semiconductors have become a critical sector in the global economy, rivalling the oil and gas industry in geopolitical significance. Global annual sales of semiconductors surpassed half a trillion dollars in 2022 (Thadani & Allen, 2023), with future projections estimating the sector's valuation to reach USD 1.3trillion by 2032 (Market.US, 2024).

The economic impact of the semiconductor industry is significant in various countries. In the United States, semiconductors contribute 0.3% to the overall GDP but influence approximately 12% of the GDP through their role as a production input. In Taiwan, the semiconductor sector accounts for 15% of the GDP, with major American tech firms relying on Taiwan-based manufacturers for nearly 90% of their chips (Arcuri and Lu, 2022). In Malaysia, the electronics and electrical (E&E) sector contributes 7% of the GDP, with semiconductors making up 65.2% of this sector (MATRADE, 2023).

The fabrication of the most advanced chips is supported by complex machinery, although a majority of chips are produced in masses due to its wide usage such as the extreme ultraviolet lithography (EUV) machine, which has over 100,000 parts. Only one company, ASML in the Netherlands, manufactures this machine, highlighting the supply chain's complexity and its dependency on specific nodes for production.

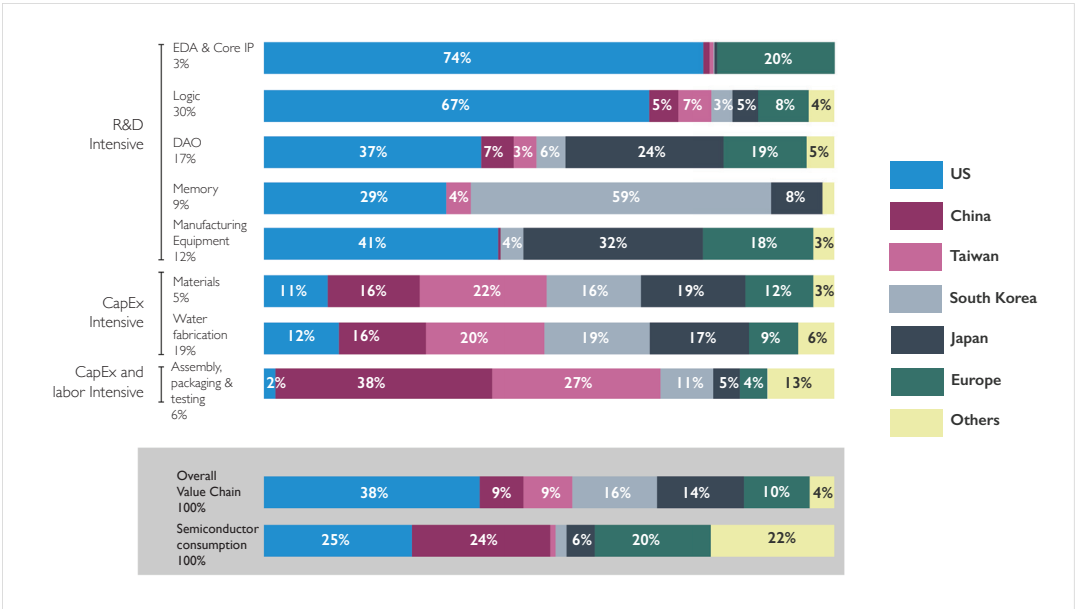
The global semiconductor supply chain is concentrated in a few regions, with each specialising in different value chain activities. The various inputs to fabrication of an integrated circuit typically crosses more than 70 international borders before the final product can be delivered to consumers (Alam et. al, 2020). This intertwined web emphasises the need for global cooperation as no single country can achieve complete independence in semiconductor production.

- In 2019, the United States comprised 38% of the total value added in the global semiconductor supply chain due to its dominant position in chip design. Although US-based firms primarily design and order these chips, Taiwan leads in chip fabrication (20%) compared to the US (12%) (Varas *et al,* 2021).

- **Taiwan plays an outsized role in the global semiconductor supply chain, particularly in the foundry (outsourced chip fabrication) market.** TSMC, a Taiwanese foundry firm, held a 55% market share in 2021, followed by South Korea's Samsung with 17% (TrendForce, 2021). TSMC's dominance is evident as it provides 35% of the world's automotive microcontrollers and 70% of smartphone chipsets.

- **Malaysia's role** in the global semiconductor market is one that goes back to the early 70s and has played a vital role in the nation's exports over the years. In 2022, its integrated circuit (IC) exports reached US$ 78.9 billion, making it the fifth-largest exporter worldwide, just behind Singapore and South Korea. The country primarily focuses on the backend of the supply chain; assembling, testing, and packaging (ATP), which contributed 13% to global back-end operations in 2023 (Malaysian Productivity Corporation, 2023). Although, the dynamic is aimed to be shifted towards the frontend of the supply chain.

Figure 1: Semiconductor industry value added by activity and region, 2019 (%)



Source: Varas et al, 2021

3. The shift to resilience and the challenges to supply chain resilience

The US response to semiconductor supply chain vulnerability underscores the shift to supply chain resilience. In response to pandemic-related disruptions, the US President issued an executive order in February 2021 to evaluate risks and ensure "resilient, diverse, and secure" supply chains which considered various risks. The US Executive Order called for reviews of supply chains across various sectors, including semiconductors, which were notably affected. The subsequent report emphasised the need for the US to rebuild domestic semiconductor production, as the nation accounts for only 6-9% of global chip production, compared to Taiwan's over 60% (The White House, 2021b).

Table 1: Two primary causes of supply chain disruptions

Disruptions	
Disasters	**The COVID-19 pandemic** surged demand for chip-containing products, while factory shutdowns in countries like Malaysia and Vietnam caused supply chain disruptions. The 2021 chip shortage impacted the US and Europe auto industry causing a $240 billion GDP loss in the US and a 20% production loss for German automakers. South Korea, which depended on exports, saw growth rates declining from this global shortage due to delays in electronic product launches and high prices for consumers. **Natural Disasters** like the 2021 Texas winter storm had forced chipmaking facilities in the US to shut down due to power cuts during this time. The 2011 Japan earthquake also strained chip production and shutdown fabrication facilities for months. An estimate saw 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.
Geopolitical Tensions	The Russian invasion of Ukraine in 2022 disrupted global food supply chains, another critical supply chain, with Ukraine being a major wheat supplier. This led to long term food price inflation which despite efforts, have not rebounded in many countries. Trade blockages and war is a key in disrupting supply chains. A potential blockade of Taiwan by China could cause significant economic losses, with a study estimating US$1.6 trillion in annual losses for industries dependent on Taiwanese chips

Policy thinking has moved away from the traditional laissez-faire approach and towards interventionist policies in relation to supply chains. As the pandemic subsided and US-China trade tensions once again resurface, the policy discourse on resilience also expanded to broader geopolitical concerns. In this context, resilience is not just about ensuring stronger trade and diversification, but also about efforts to re-shore, near-shore, or on-shore vital production capacity in case of disruption. However, this paper considers that domestication and trade restrictions are not the best option for supply chain resilience.

The push for more indigenous chip production capabilities to enhance supply chain resilience faces significant hurdles. While policymakers advocate for interventionist measures, industry experts caution against the feasibility of such plans. **The challenges towards building resilience** include high upfront investments, rising costs for consumers, lack of skilled labour, and security concerns arising from the geopolitical trade issues.

- **High Upfront Investments:** Reshoring semiconductor production requires substantial initial investments, posing a barrier to achieving self-sufficiency. Estimates suggest upfront investments ranging from US$900 billion to over US$1, 225 billion would be needed to cover consumption levels and accommodate future

growth. China, for example, would need to commit over a trillion dollars over several years to catch up in chip manufacturing if the global chip industry invests US$ 100 billion per year in capital. Even with government incentives, such as those rapidly developed in recent years, these costs remain daunting.

- **Rising Costs for Consumers:** As countries aim to bolster supply chain resilience, semiconductor firms may need to transfer some incremental costs to device makers, resulting in higher semiconductor prices. Estimates suggest a shift toward self-sufficient supply chains could increase semiconductor prices by 35% to 65%. Disengagement from certain markets, such as China, may lead to loss of cost-effective production and strategic materials, potentially raising electronic device prices.

- **Lack of Skilled Labor:** A critical issue hindering countries like Malaysia from advancing in the semiconductor value chain is the shortage of skilled labour. Wafer fabrication demands specialised expertise and extensive training, yet Malaysia faces a shortfall of engineers. With only 5,000 engineering graduates annually against an industry demand of 50,000, the country struggles to bridge this gap. Limited skilled labour development impedes Malaysia's progression in semiconductor manufacturing.

- **Geopolitical Tensions and trade restrictions:** Particularly between the US and China, have catalysed efforts to fortify semiconductor supply chains. Export controls and restrictions threaten to disrupt global chip flows, raising concerns over supply chain dependencies. Taiwan's semiconductor dominance poses a critical chokepoint, where amidst these tensions, Taiwan is expanding investments southwards, creating an investment spillover effect for Malaysia as firms look to near-shore. However, given the volatility of global relationships, the ongoing decoupling between the US and China may force investors in other countries to ultimately choose sides and thereby lose access to the other's markets.

4. Trade and supply chain resilience

Countries aiming to secure chip supply as well as benefit from reshoring can aim for partial domestication of the value chain, but it is costly. Malaysia is well positioned to attract investments in this sector given the existing ecosystem, but would be unable to compete on monetary incentives alone. Malaysia should therefore consider complementary strategies such as deeper multilateral investment and trade integration so that the net effect reduces costs for investors that rely on complex supply chains.

Facilitating resilience through trade agreements is vital as these agreements play a crucial role through reducing trade barriers and fostering collaboration. Research indicates that trade carried out through deep regional trade agreements (RTAs) exhibits greater resilience compared to non-RTA trade or shallow agreements, as it was attributed to lower trade costs and better trade conditions (Nicita and Saygili, 2021).

The key benefit of the notion to trade and through trade agreements is the diversification of suppliers as it provides access to more materials with a lower cost (Ciurak et al, 2020). Participant feedback from IDEAS' roundtable on supply chain resilience also suggests that companies are working towards reducing the risks that arise from single-sourcing. Deeper trade relationships that provide more resilience was also suggested to arise through multilateral agreements such as the CPTPP and RCEP.

- **By ensuring access to multiple sources for critical components, trade agreements enable countries to mitigate supply shocks and reduce macroeconomic volatility.** In the wake of the pandemic, the OECD recommended pillars such as predictability, transparency, and international regulatory cooperation to foster open markets, thereby promoting smoother supply chain movements amidst crisis (OECD, n.d). Trade diversification and mechanisms for maintaining openness, rather than trade restrictions and reshoring are encouraged for enhancing supply chain resilience in the long term.

- **Taiwan's potential role in the CPTPP offers significant opportunities for enhancing supply chain resilience, particularly in the semiconductor sector.** While challenges exist, such as geopolitical considerations and opposition from certain members, benefits that would accrue from Taiwan joining the CPTPP would include reduced vulnerability to trade restrictions. Moreover, Taiwan's collaboration with ASEAN Member States can further bolster supply chain resilience, leveraging the region's economic specialties and facilitating semiconductor production in Southeast Asia-based facilities.

- **Currently, Taiwan has already established trade relationships with members of the CPTPP, namely Japan, Singapore and Malaysia which ranked as the top 10 trading partners of Taiwan.** Moreover, 30.4% of Taiwan's total FDI came from the CPTPP members. Focusing on Malaysia, it was estimated that Taiwan's accession into the GDP can increase the nation's GDP by US$ 517 million, paired with an additional 20,000 job opportunities.

Given Malaysia's target of moving up the value chain and establishing more front-end activities, paired with convenient geographical location, Malaysia provides an ideal investment destination for Taiwanese semiconductor companies looking to diversify to mitigate geopolitical risks. In 2023, Taiwan stood as Malaysia's fifth-largest trading partner, while Malaysia stood as Taiwan's eighth-largest (MIDA, 2023). Malaysia and Taiwan have a substantial existing economic relationship, particularly when it comes to semiconductors, with over 50 Taiwanese multinational semiconductor enterprises in the country (Ruehl, 2024). Given that Malaysia is equipped with the back-end technology of the semiconductor supply chain, it is possible that when paired with Taiwan's front-end expertise significant opportunities can be manifested for Malaysia in tandem with Taiwan's potential accession to the CPTPP and the move to diversify supplier locations for resilience.

Focus on resilience through increased multilateral cooperation. However, despite the challenges faced by Taiwan in accessing the CPTPP, it is suggested that Taiwan can still pursue supply chain resilience through expanded cooperation with ASEAN countries. In lieu of the CPTPP, other bilateral or multilateral cooperation mechanisms, particularly in the semiconductor supply chain, can mitigate risks and enhance long-term resilience by diversifying supply chains and increasing market access for investments. Emphasising trade openness and cooperation offers a viable pathway to strengthen global supply chain resilience amidst evolving geopolitical tensions.

5. Conclusion

In conclusion, trade agreements and regional cooperation play a pivotal role in strengthening supply chain resilience. If resilience is the goal, diversification and trade openness could be the answer. By promoting trade openness, diversification, and collaboration, countries can mitigate the impact of disruptions and enhance economic resilience. Taiwan's potential accession to the CPTPP presents promising opportunities for deepening regional integration and fostering a more resilient semiconductor supply chain.