Malaysia's Position in the Global E&E Value Chain and Prospects

Introduction

The electrical and electronics (E&E) industry is a critical linchpin in the global economy. It powers the digital transformation that touches all aspects of modern society. In this dynamic landscape, Malaysia has carved out a significant position to become an integral player within the global E&E value chain (E&E GVC). Leveraging its strategic geographical location, robust infrastructure and skilled workforce, Malaysia has emerged as a critical hub for E&E production. Recent developments ranging from geopolitical shifts to the artificial intelligence (AI) led revolution have brought immense challenges and opportunities in the E&E industry. The E&E GVC is being recalibrated as countries adopt aggressive industrial policies to protect their economic, security and socio-political interests. These changes have significant implications for small, open economies such as Malaysia, affecting production, trade and income growth.

Against this backdrop, this article presents a primer on semiconductors, the E&E GVC and recent trends in the global tech cycle. It then analyses Malaysia's current standing in the E&E GVC, examining its contributions to the domestic economy, recent export performance and near-term outlook. The implication of key megatrends on future growth prospects and their challenges to Malaysia's E&E industry are also explored. Lastly, the article discusses strategies to seize the opportunities that would further solidify Malaysia's position in the ever-evolving global semiconductor ecosystem.

The global E&E value chain is highly complex and interconnected across countries

As a critical part of many capital and consumer goods, the E&E industry has been a key catalyst for productivity gains and innovation in most other industries and economic sectors. At 18.8% share of global trade in 2024,[1] the global E&E industry is also highly integrated across regions, leveraging free trade to move inputs and products between nations.

At its core, semiconductors are the 'brains' of all modern electronic devices, accounting for 32.7% share of global E&E exports. They are critical components that provide essential functionality to process data, store information and control the function and communication with other devices in various end-segments. Semiconductors are typically divided into three main types of chips: logic, memory as well as discrete, analog and others (DAO) (Diagram 1). Meanwhile, the complexity of semiconductors is determined by their process node size.[2] Much of the current technological breakthroughs involve making nodes smaller. This allows for the development of highly advanced and cutting-edge chips with greater performance and efficiency. Nevertheless, older or legacy chips remain integral in most end-segments due to their cost-effectiveness and reliability. Given its intricacy, semiconductor manufacturing is distinguished by a highly specialised and often geographically dispersed but interconnected value chain. This value chain, along with a host of supporting activities, form a complex and globalised semiconductor ecosystem.

In general, the value chain can be divided into two main sections: the front-end and the back-end (Diagram 1). The front-end of the value chain consists of research and development (R&D), integrated circuit (IC) design and wafer fabrication of the different types of chips. These processes usually require highly skilled expertise and are both capital- and technology-intensive. Meanwhile, the back-end of the value chain comprises assembly, testing and packaging (ATP) activity. This is a crucial step to ensure that the chip's function and performance are reliable, durable and ready for integration with other E&E components in various devices of the end-segments. ATP activity is relatively more labour-intensive and less technically intricate. However, this activity has progressed to become more complex and capital-intensive because of advances in packaging technology.[3] At the final stage, once these devices are integrated, they are then handled by business services entities for marketing, distribution and sales. Complementing this value chain is an extensive support ecosystem that produces the materials, specialty chemicals, machinery and equipment, software design and core intellectual property for semiconductor manufacturing activities.

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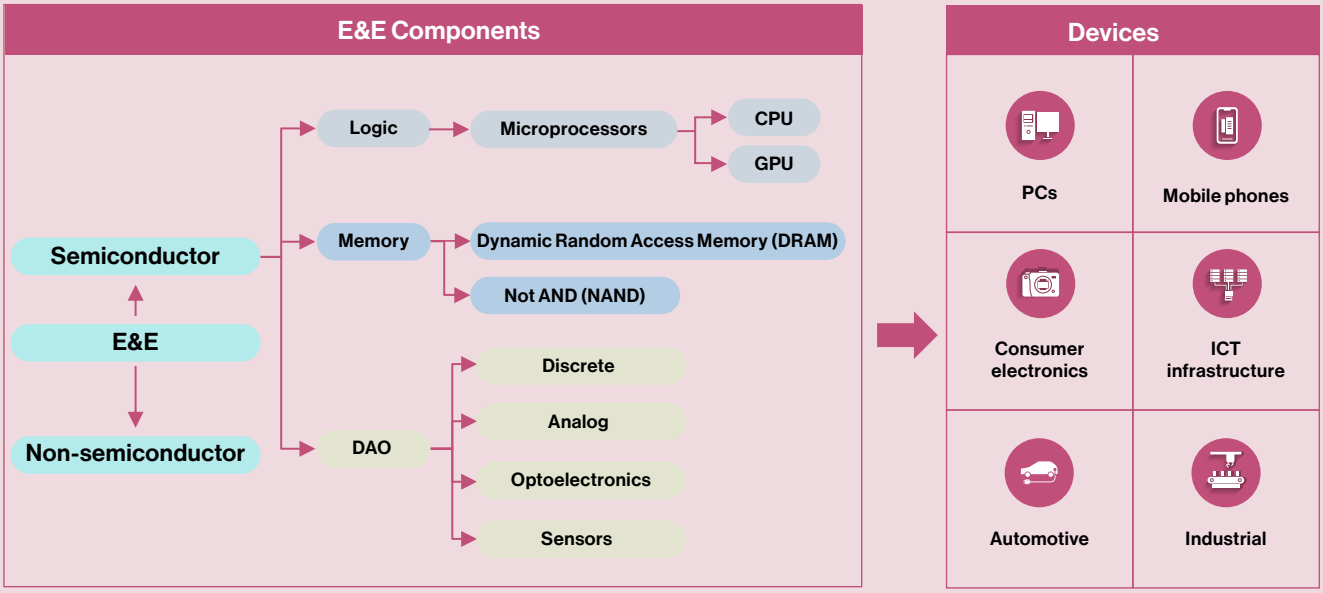
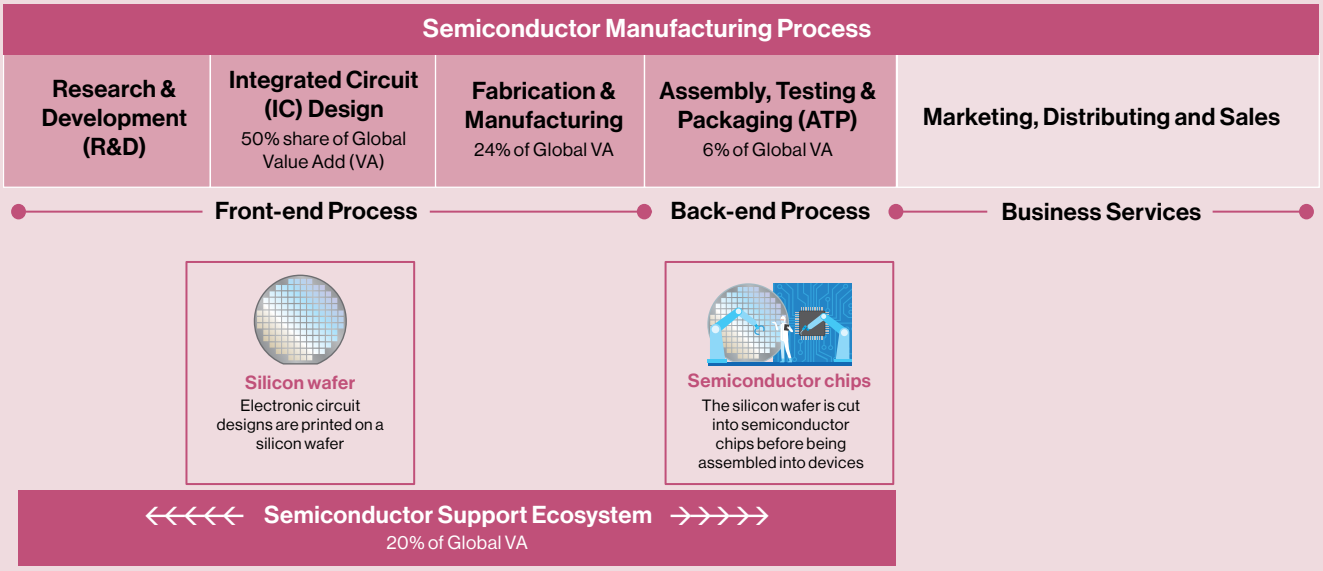
1 Estimated using S&P Global Trade Atlas data.
2 'Cutting-edge' chips generally apply to process nodes at 5nm or below, whereas 'highly advanced' chips are those within 10nm to 7nm. Meanwhile, the US CHIPS and Science Act 2022 defines 'legacy' chips as those produced at 28nm or larger.
3 Historically, chip packaging entails a straightforward bonding process onto external systems. However, recent innovation in advanced packaging employs 2.5D and 3D techniques, where multiple chip layers are stacked and bonded closer together for greater performance and energy efficiency.

Diagram 1: Stylised Illustration of the E&E Value Chain

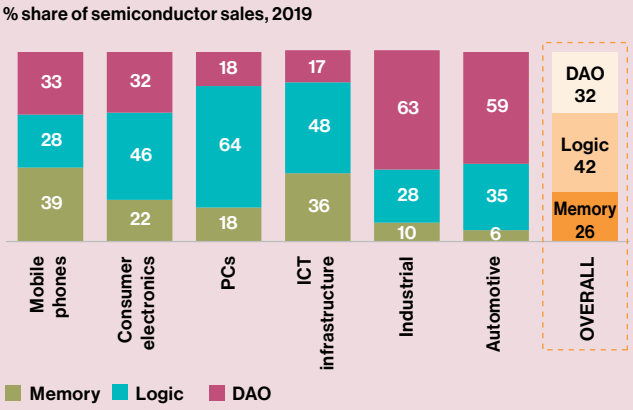




Note: Under Memory, DRAM refers to short-term memory component for active computing tasks while NAND functions as long-term memory for data retention and file storage.

Source: Semiconductor Industry Association and Boston Consulting Group

Chart 1: Global Semiconductor Sales by Type of Chips



Source: Boston Consulting Group, Gartner and World Semiconductor Trade Statistics

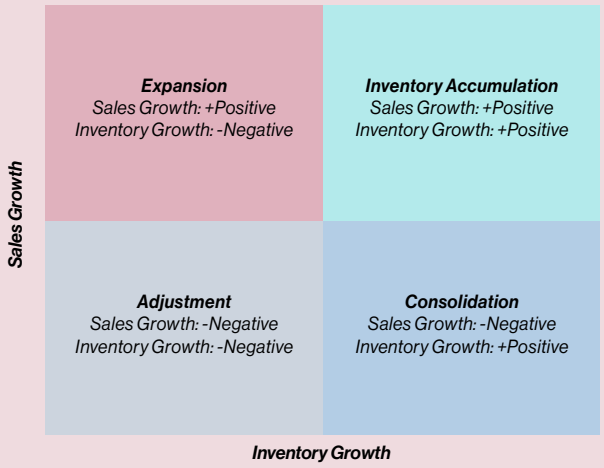
Global demand for semiconductors is mainly dictated by the growth trends of the various end-segments. In terms of breakdown by type of chips, the end-segments collectively comprise 42% logic, 32% DAO and 26% share in memory chips (Chart 1). However, the exact composition of chips differs for each end-segment respectively. Therefore, the growth trend in the demand for each type of chip will also vary over time depending on market-specific factors influencing the various end-segments.

The global tech cycle is currently in an expansion phase

The global semiconductor ecosystem underwent significant changes in recent years, influenced by both cyclical and structural factors. The 'tech cycle', as proxied by global semiconductor sales, is prone to large growth swings. These cycles are typically divided into four phases namely adjustment, expansion, inventory accumulation and consolidation. The phases reflect the changing demand and supply conditions as characterised by the trend in the sales and inventory growth of chips (Chart 2).

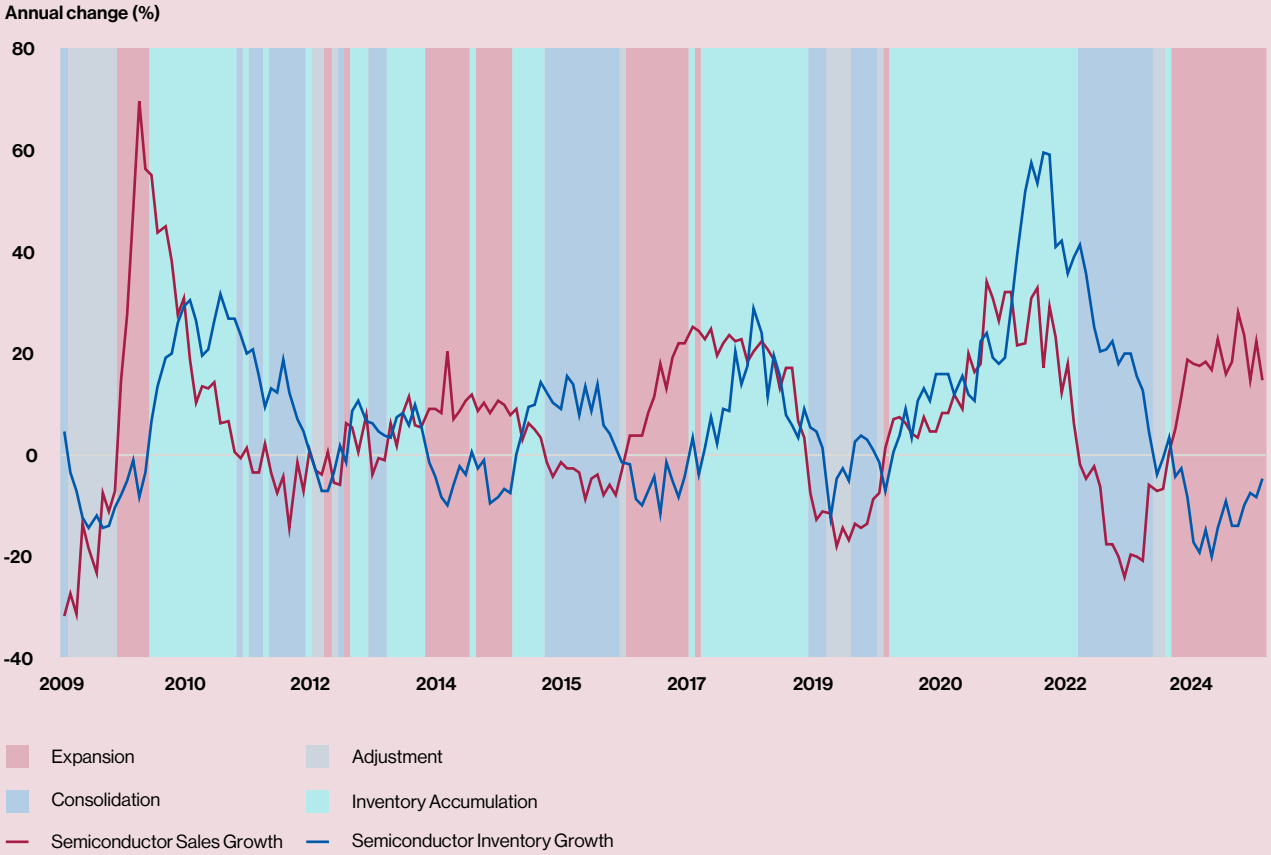
In the last five years, the shifting phases can be traced through major developments and events affecting the global tech cycle (Chart 3). During the COVID-19 pandemic, demand-supply dynamics for semiconductors shifted dramatically. The rise in remote work and online activities led to a broad-based surge in demand across most end-segments such as PC, mobile phones and consumer electronics. Firms aggressively ramped up production and inventories to meet rising demand amid supply chain disruptions and lockdowns. By June 2022, as pandemic-driven demand waned, sales growth slowed and inventory started building up, prompting firms to shift from expansion to consolidation. Subsequently, firms entered an adjustment phase as declining sales forced them to reduce excess inventories.

Chart 2: Phases of the Global Tech Cycle



Source: Adapted from Monetary Authority of Singapore Macroeconomic Review, April 2024.

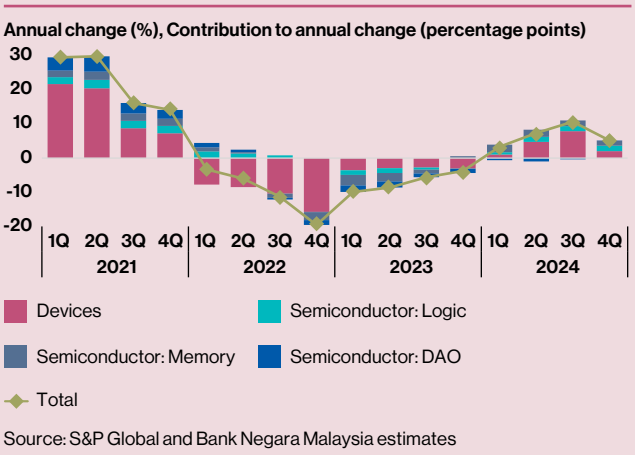
Chart 3: Global Semiconductor Sales and Inventory Growth by Tech Cycle Phase



Note: The global tech cycle comprises of four phases: (i) expansion (+ve sales growth, -ve inventory growth); (ii) inventory accumulation (+ve sales growth, +ve inventory growth); (iii) consolidation (-ve sales growth, +ve inventory growth) and (iv) adjustment (-ve sales growth, -ve inventory growth). Global inventory is proxied by the average semiconductor inventory levels in the US, Korea and Chinese Taipei, weighted by their export shares.

Source: Adapted from Monetary Authority of Singapore Macroeconomic Review, April 2024 using data from CEIC, World Semiconductor Trade Statistics and Bank Negara Malaysia estimates

Chart 4: Global E&E Exports Growth by Product



Source: S&P Global and Bank Negara Malaysia estimates

By late 2023, a resurgence in sales emerged and inventories were drawn down, spurred by technology advancement and hardware replacement cycles. The global tech cycle experienced an upswing in 2024 with semiconductor sales growth of 19.1% (2023: -8.2%). The recovery was driven mainly by logic and memory chips (Chart 4), owing to high demand in the PC and information and communication technology (ICT) infrastructure end-segments. This reflects the pivot towards AI-related devices and expansion of new capacity for cloud computing and data centres. The recovery, however, remains uneven with sluggish improvement in other end-segments. Mobile phone demand is soft due to longer replacement cycles, while excess inventory accumulation dampened DAO chip demand in the automotive end-segment.

Beyond cyclical trends, more lasting structural shifts in aggregate chip demand have been driven by technological advancements such as Industry 4.0 and AI. In addition, flexible working arrangements and rising geopolitical fragmentation have also reshaped the structure of the E&E industry. Ongoing structural shifts will continue to shape the industry and will provide strong support to the current expansion phase of the global tech cycle.

Malaysia is deeply integrated into the global E&E value chain

E&E has been one of the major drivers of the nation's industrial development. Over the past five decades, Malaysia's E&E industry has experienced rapid progress. The E&E industry now accounts for 40% of Malaysia's total gross exports, contributing 3.7% to global E&E exports and capturing a notable 7.3% share of global semiconductor exports in 2024. It is also a vital source of employment, supporting 614,051 jobs[4] with an average monthly wage of RM4,019, well above the manufacturing sector's average of RM3,448. It also makes up 7.4% of total output, with a compounded annual growth rate (CAGR) of 6.4% between 2015 and 2024, higher than the GDP CAGR of 3.8%. Overall, Malaysia is now the world's ninth largest E&E exporter.[5]

Malaysia has gained a comparative advantage within the global semiconductor ecosystem by developing specialised capabilities in the E&E value chain. It has an entrenched presence in the back-end particularly the outsourced semiconductor assembly and test (OSAT) players, holding 13% share of global ATP activity, as well as some presence in the front-end (Table 1). Further supporting the value chain is a wide array of domestic automated test equipment (ATE) makers.

In terms of products, 64% share of Malaysia's E&E exports are semiconductors while 36% are comprised of devices such as parts for computers and telephones (Chart 5). Within semiconductor exports, logic chips make up the largest share at 49.5%, followed by DAO (43%) and memory (7.5%). Given the product mix, the recovery for Malaysia's E&E exports was broadly gradual in 2024. The initial recovery in the early part of the year lagged regional peers. This was primarily due to Malaysia's limited presence in advanced high-bandwidth memory chips (Table 2). Nevertheless, the recovery took hold in the second half of 2024 as the memory, logic chips and devices segment began to significantly improve (Chart 6).

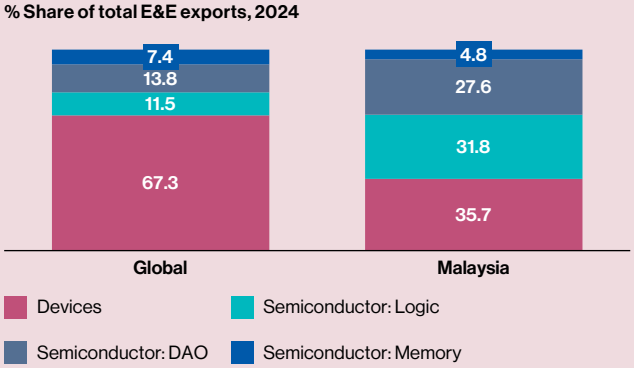
[4] Source: Monthly manufacturing data (2024 average), Department of Statistics, Malaysia.
[5] As of 2024 based on Global Trade Atlas (GTA).

Table 1: Malaysia's Involvement in the Global E&E Value Chain

Devices		Front-End Activities			Back-End Activities
		R&D	Design	Fabrication	ATP
Electronic Components		Low	Medium	Medium	High
Consumer Electronic		Low	Low	Medium	High
Industrial	Computer Equipment	None	Low	Medium	High
	Communication Equipment	None	None	High	Medium
Electrical		Low	Medium	High	High

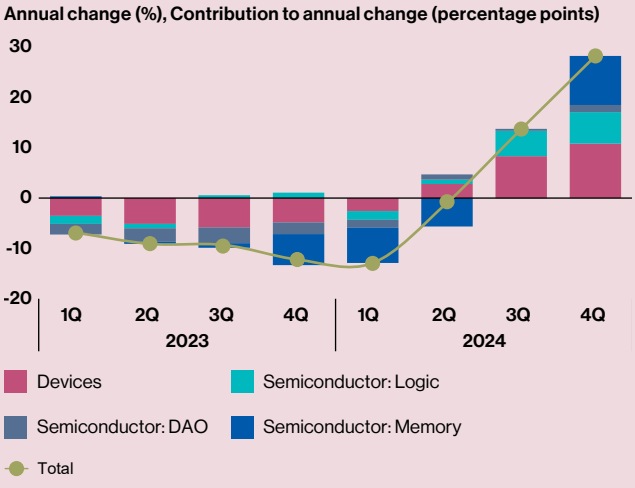
Source: Ministry of Investment, Trade and Industry, Malaysia

Chart 5: E&E Exports by Product



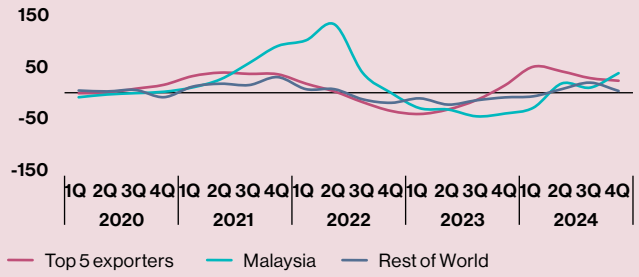
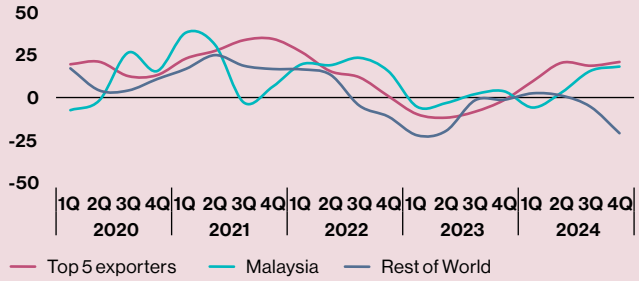
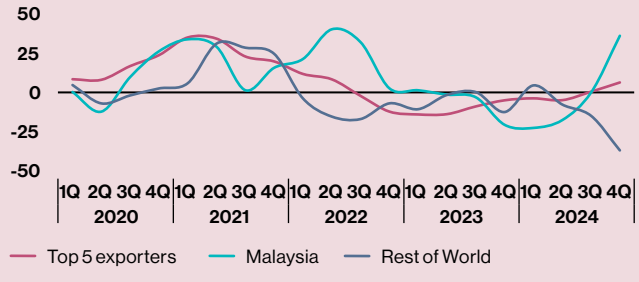
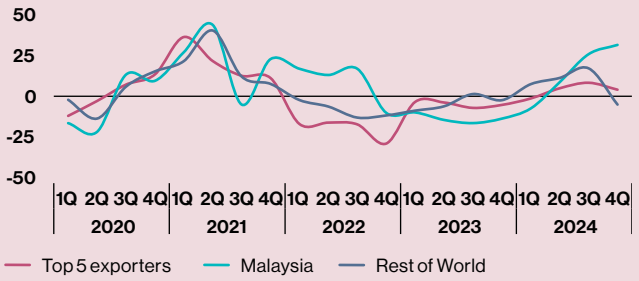
Source: S&P Global and Bank Negara Malaysia estimates

Chart 6: Malaysia E&E Exports Growth by Product (USD)



Source: S&P Global and Bank Negara Malaysia estimates

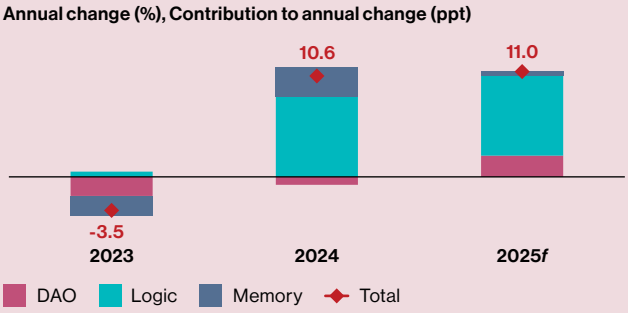
Table 2: Comparison of Malaysia's E&E Exports Growth with Frontrunner Countries by Products

E&E Product	Development
Semiconductor: Memory Annual change (%) 	Malaysia's memory chip export growth in 2023 and the first half of 2024 was initially lagging the frontrunner economies due to limited presence in high bandwidth chips but has since recovered.
Semiconductor: Logic Annual change (%) 	Malaysia's logic chips exports growth move in tandem with other frontrunner countries such as China, Korea, Singapore and the US, benefitting from increased demand from AI servers and data centres globally.
Semiconductor: DAO Annual change (%) 	Overall, DAO chip export growth continues to lag memory and logic chips amid uneven recovery particularly in the automotive and industrial end-segments. For Malaysia, export growth were broadly in line with frontrunner countries and improved further in the fourth quarter of 2024.
Devices Annual change (%) 	Malaysia leads in export growth of devices driven mainly by demand for automated data processors.

Note: The top five E&E export frontrunners may differ for each product but are largely comprised of Hong Kong, China, the US, Korea, Chinese Taipei, Germany and the Netherlands.

Source: S&P Global and Bank Negara Malaysia estimates

Chart 7: Malaysia-implied WSTS Semiconductor Sales Forecast by Type of Chips



f Forecast

Note: The Malaysia-implied WSTS semiconductor sales is constructed using the aggregate WSTS global semiconductor forecast by product weighted by Malaysia's semiconductor export shares by product in 2024.

Source: World Semiconductor Trade Statistics and Bank Negara Malaysia estimates

Outlook and drivers for Malaysia's E&E industry

Despite heightened geopolitical tensions and potential trade and investment restrictions, Malaysia's E&E industry recovery is expected to be sustained. It will continue to reap the benefits from the ongoing global tech upcycle. The World Semiconductor Trade Statistics (WSTS) forecasts a continued strong expansion for the global semiconductor industry with a growth of 11.2% in 2025 (2024: 19.1%). This will be driven mainly by memory and logic chips supported by a wider range of end-segments. Demand for PC and mobile phones are expected to grow amid the hardware replacement cycle, rising demand for AI-enabled devices and further adoption of the 5G network. Meanwhile, DAO are expected to expand amid the continued rising chip content per vehicle in the automotive segment, albeit more modestly compared with memory and logic chips.

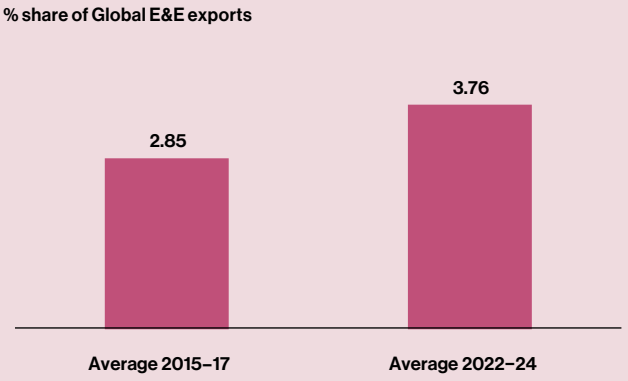
For Malaysia, the recovery trend in E&E exports across all major product groups is consistent with leading E&E players globally. Estimation of Malaysia's implied semiconductor sales[6] suggest that it could grow to 11% in 2025 (2024: 10.6%), driven primarily by logic chips (Chart 7). The prospect is further corroborated by findings by the domestic E&E industry. According to the Malaysia Semiconductor Industry Association's (MSIA) quarterly survey for the fourth quarter of 2024, 66% of companies expressed optimism about their overall outlook for the next 12-months.

Growth opportunities and challenges for Malaysia's E&E industry

At present, the global economy is confronted with two megatrends with profound implications for the E&E value chain. First, heightened geopolitical tensions have increased economic fragmentation as nations trade and invest more with those they deem as geopolitically allied. Rising protectionism and imposition of tariff and non-tariff barriers have diverted international trade and investment flows. This has caused supply chain disruptions, technology restrictions and elevated uncertainties. Second, the digital revolution, marked by advances in AI, 5G and EV adoption, could greatly transform economic activities. Of significance, AI has the potential to disrupt labour markets notably those involved in cognitive and non-routine tasks. The IMF estimates that about 40% of global employment is exposed to AI,[7] suggesting that even skilled jobs will need to adapt to the new technology. At the intersection of these two megatrends is the rise of 'techno-nationalism', whereby technological prowess becomes an imperative for national security and economic prosperity. This has led governments to protect their domestic E&E industries while attempting to onshore the semiconductor ecosystem entirely or build a supply chain with allied countries.

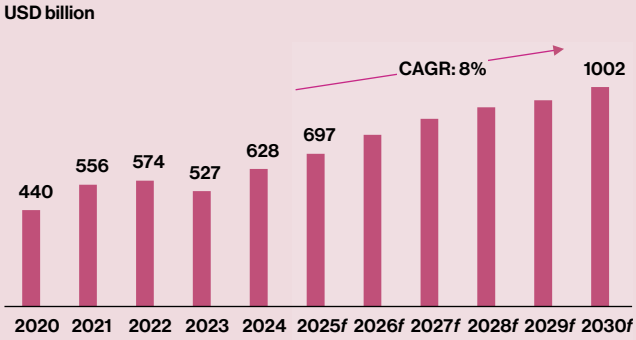
[6] Estimated using the aggregate WSTS global semiconductor forecast by product weighted by Malaysia's semiconductor export shares by product in 2024.
[7] IMF (2024), Gen-AI: Artificial Intelligence and the Future of Work.

Chart 8: Malaysia's Share of Global E&E Exports



Source: S&P Global and Bank Negara Malaysia estimates

Chart 9: Global Semiconductor Market, 2020–30



f Forecast

Source: World Semiconductor Trade Statistics, PwC Semiconductor Centre of Excellence and Bank Negara estimates

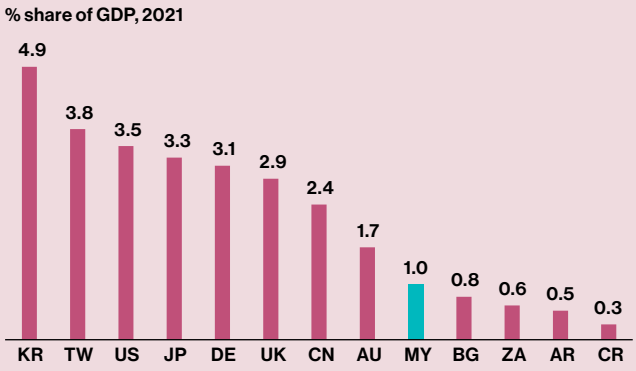
In this evolving landscape, there is potential for Malaysia's E&E industry to capitalise on emerging opportunities by building on its existing solid foundation and moving to the frontier of higher value-added activities. As countries and MNCs reassess their supply networks amid the ongoing E&E GVC recalibration and bifurcation along dominant trading blocs, many major players are pursuing a strategy to spread out their operational and production base. Given Malaysia's neutrality and diversified export structure for both products and market destinations, the country is favourably positioned to secure a larger share of the trade and investment diversion, therefore helping attenuate the costs of economic fragmentation. This is already evidenced by the larger share of Malaysia's E&E exports within the global E&E market (Chart 8).

Meanwhile, the digital revolution is also providing a more enduring support to the global demand for semiconductors, with the market size projected to reach USD1 trillion by 2030 (Chart 9). With rapid developments in AI, the rising demand for cutting-edge chips has led to advanced packaging becoming the latest frontier for innovation. At the same time, the existing cluster of Malaysian IC design companies is at the stage where they are ready to develop chips in-house. These positive developments accord Malaysia the potential to ascend the E&E GVC. This entails expanding its foothold in the more capital and technology-intensive front-end processes while continuously innovating on its prevailing strength at the back-end. Amid the current investment upcycle,[8] there are forthcoming investments that would deepen Malaysia's integration into the global semiconductor ecosystem. In 2024, MIDA reported E&E manufacturing investment approvals amounting to RM55.8 billion (2023: RM 85.4 billion). These investment approvals were mainly for capacity expansion and diversification of semiconductor production, such as advanced packaging and wafer fabrication.

Amid these positive developments, the domestic E&E industry needs to address several key challenges. Among them, the struggle for talent is the most pressing. Based on MSIA survey findings, 72% of E&E firms remained focused on recruitment to cope with talent shortages and high turnover rates, particularly for engineers.[9] The insufficient availability of highly skilled workers has become a core challenge faced by companies (35% of E&E firms surveyed). If left unaddressed, this could potentially reduce new investments, lead to lost opportunities on new projects and delay Industry 4.0 deployment. Equally critical is the limited creation of home-grown intangible capital[10] and technologies. This can be observed from the low gross R&D expenditure (Chart 10) and domestic value added embedded in gross E&E exports compared to other countries (Chart 11).

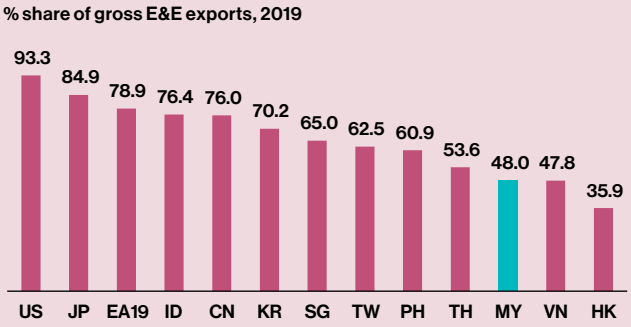
[8] Please refer to detailed analysis on Malaysia's investment upcycle in the EMR2024 box article 'Deciphering Investment Cycles in Malaysia'.
[9] Malaysia Semiconductor Industry Association (MSIA) 4Q24 Quarterly Pulse Survey.
[10] E.g. intellectual properties (IPs), computer software and databases.

Chart 10: Gross Expenditure on R&D



Source: Organization for Economic Cooperation and Development and New Industrial Master Plan 2030

Chart 11: Domestic Value Added Embedded in Gross Exports of E&E

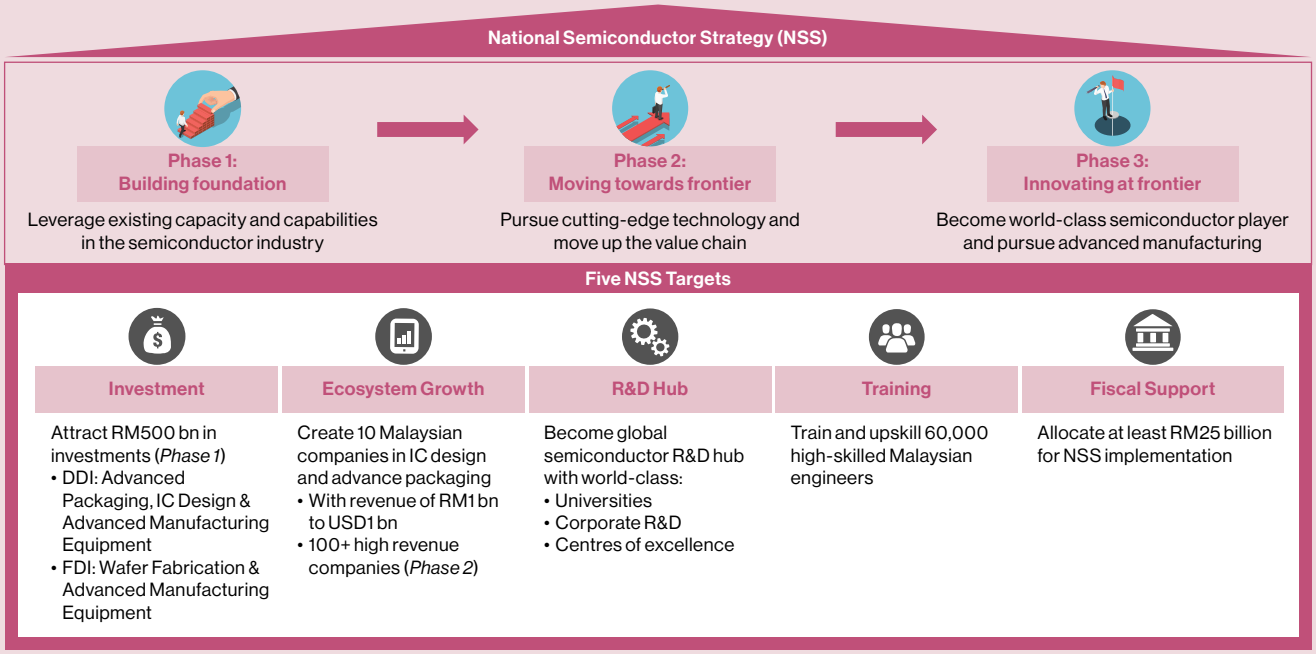


Source: OECD Trade in Value Added 2023 Edition and Bank Negara Malaysia estimates

Policy imperatives to transform Malaysia's E&E industry

Recognising the urgency to drive Malaysia's E&E industry forward amid intense regional competition, the Government has launched the National Semiconductor Strategy (NSS). The NSS complements the New Industrial Master Plan (NIMP 2030) and sets the overarching roadmap to enhance Malaysia's role in the E&E GVC by creating an ecosystem driven by dynamic Malaysian firms and world-class talent (Diagram 2). Guided by the National Investment Aspirations (NIAs), the NSS emphasises attracting domestic investments focusing on IC design, modernising OSAT and advanced packaging, as well as FDI in wafer fabrication and equipment manufacturing. It also aims to develop a local talent pipeline of 60,000 high-skilled engineers. Collaboration in chip R&D between academia, industry and Government is prioritised as well. These objectives are aimed at not only raising the nation's economic complexity but also creating high-value job opportunities and extend domestic linkages within the E&E industry. Meanwhile, the National Energy Transition Roadmap (NETR) will support the low-carbon transition of the E&E industry in becoming more sustainable and efficient.

Diagram 2: Stylised Illustration of the National Semiconductor Strategy (NSS)



Source: Ministry of Investment, Trade and Industry, Malaysia

Alongside the execution of these policies, there is scope to bolster Malaysia's E&E industry even further by boosting domestic E&E capabilities to remain competitive and seize new opportunities. First, there needs to be greater investment into ecosystem enhancement. It is paramount that Malaysia continues to attract both domestic investment and FDI, capitalising on its neutrality in an increasingly fragmented global environment. In addition to capturing opportunities in highly advanced and cutting-edge chip development, there should be a strong focus on continuous innovation in legacy chip production. This will require domestic SMEs to move up and deepen their integration into the E&E GVC. Creating a supportive business environment for small businesses to grow into medium-sized and large enterprises is crucial to foster more innovation and higher productivity. Digitalising the supply chain, including adopting smart manufacturing and industry 4.0 solutions through TechUp,[11] a key mission under NIMP 2030, would also enhance overall SME productivity and enable them to compete on a more even footing with global players.

Second is to strengthen supply chain resiliency against potential disruptions through the expansion of bilateral trade agreements. To date, Malaysia has signed and implemented 16 Free Trade Agreements (FTAs), including seven bilateral and nine regional agreements. These agreements[12] benefit the E&E industry by improving product competitiveness, easing entry into new markets and protecting investors' rights. Meanwhile, technical facilitation should be provided to local players so that their product and service offerings meet global procurement standards. Third, Malaysia must pursue a more sophisticated and integrated research, development, commercialisation and innovation (RDCI) strategy to advance technology as a key conduit for innovation in the E&E industry. This strategy should strive to build stronger technology alliances on research initiatives to pool resources and increase the success rate of commercialisation. Specifically, there is an opportunity for domestic players to collaborate locally and internationally to co-develop advanced packaging technology given that it is a nascent field. Further, to optimise investments in RDCI activity for semiconductor development, there is potential to restructure existing grants[13] or create dedicated R&D funds to meet the current needs more effectively.

Fourth, it is crucial to mobilise financing of differing modalities to cater to investments with varied risk-return profiles. This ranges from the participation of financial institutions to tapping the capital market such as venture capital and private equity to support the growth of innovative tech start-ups. Complementing these modalities are the joint capital pledges by government-linked investment companies (GLICs) through the GEAR-uP programme.[14] The programme will support investment in local firms in high-value industries, including semiconductors, throughout its business growth stages. Finally, there needs to be pragmatic reforms to labour market and immigration policies. Easing the entry of critical foreign talent will help plug shortages in the immediate term while expediting technology transfer and complementing local high-skilled talent development. Meanwhile, improving and promoting STEM education in schools and universities is vital for developing a sustainable talent pipeline, thereby ensuring durable growth and innovation in the industry.

Conclusion

The world is becoming increasingly reliant on semiconductor technology to spur future growth and safeguard economic security. Amid these disruptive global shifts, Malaysia is facing the prospect of repositioning itself as a neutral and leading partner in the E&E GVC. Therefore, Malaysia must be proactive in shaping the ongoing recalibration to its maximum benefit. To succeed on this path, the domestic E&E industry must shift its paradigm and raise its capabilities to compete on a global scale. Building upon its mature ecosystem and existing strengths in the ATP process, there is a window of opportunity to pivot towards greater value creation at the chip R&D, design and fabrication stage. To attract high-quality tech investments, a whole-of-nation commitment is needed to tackle immediate challenges and enhance the comparative advantage of the industry by fostering a culture of innovation. This means having the right set of incentives, business facilitation, talent development and funding support. Ultimately, creating a more dynamic and resilient domestic semiconductor ecosystem will not only be able to withstand fluctuations in global tech cycles, but also secure Malaysia's long-term economic growth prospects and prosperity for the *rakyat*.

[11] The NIMP2030 'Mission 2: Tech up for a digitally vibrant nation' aims to embrace technology and digitalisation to drive innovation, enhance productivity and create new opportunities for economic growth.

[12] Free Trade Agreements (FTAs) are vital for the E&E industry, especially those involving key markets in global supply chains, such as the ASEAN Trade in Goods Agreement (ATIGA), Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), Regional Comprehensive Economic Partnership (RCEP), Malaysia-Japan Economic Partnership Agreement (MJEPA) and Malaysia-Australia Free Trade Agreement (MAFTA). Additionally, upcoming agreements like the Malaysia-Korea FTA (MKFTA) and Malaysia-EU FTA (MEUFTA) offer potential benefits for the industry.

[13] For example, the R&D Fund and Innofund under the Ministry of Energy, Science, Technology, Environment & Climate Change (MESTECC), Technology Development Fund and Strategic Research Fund under the Ministry of Science, Technology and Innovation (MOSTI), and the Cradle Investment Program by Cradle Fund Sdn Bhd.

[14] The GEAR-uP programme is a Ministry of Finance (MOF)-led initiative which aims to deploy a collective RM120 billion over the next five years. The GLICs involved are Khazanah Nasional Bhd, Employees Provident Fund (EPF), Retirement Fund (Incorporated), Permodalan Nasional Bhd, Lembaga Tabung Haji and the Armed Forces Fund Board.

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