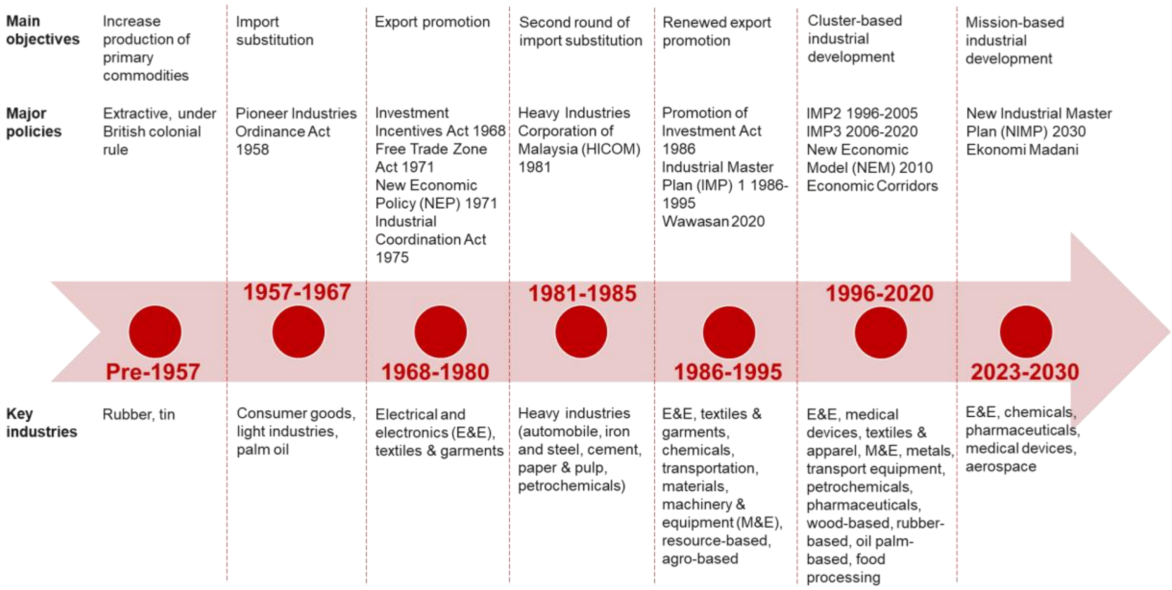
3. NIMP 2030 and Semiconductors[99]

A mission of the New Industrial Master Plan (NIMP) 2030 is to advance economic complexity. Semiconductors are a key focus, particularly chip design and fabrication. There are also other product areas that are of high economic complexity and yet related to existing know-how, such as certain specialty chemicals and gases, components, and equipment. Additionally, investment in new and emerging technologies, such as advanced packaging, compound semiconductors, and graphene-based semiconductors, could yield large economic payoffs.

1. **Malaysia has undergone substantial industrial transformation in just six decades, shifting from a resource-based economy to a diversified industrialized economy.** This transformation largely reflects the evolution of Malaysia's industrial policy, from extractive policies under British colonial rule to import-substituting industrialization and export-oriented industrialization after independence (Figure A3.1). These changes were manifested in a shift in the export composition—heavy concentration in rubber and tin before 1980, and gradually expanding the product mix to manufactured goods (especially electrical and electronics), oil and gas, and palm oil (Figure A3.2). The key incentives that enabled rapid structural change included free trade zones, tariff protection, tax holidays, investment tax credits, and more liberal foreign equity participation to attract FDIs.

Figure A3.1. Shifts in Malaysia's Industrial Policy



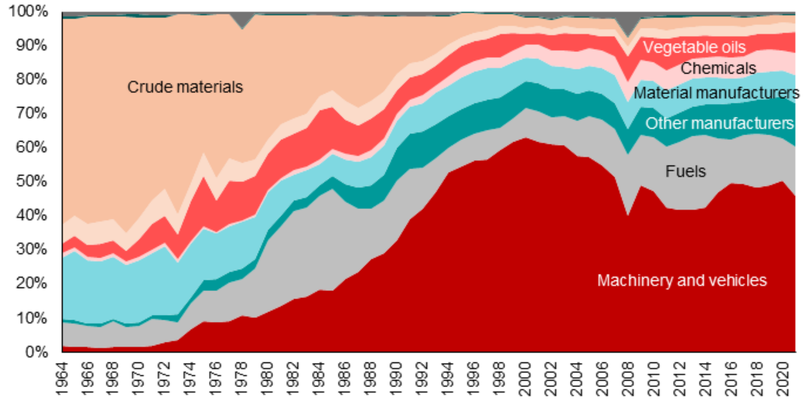
Source: Various national plans; AMRO staff illustrations

2. **However, Malaysia appeared to have faced premature deindustrialization in the aftermath of the Asian Financial Crisis (AFC), but the pace of decline in the output share of manufacturing has slowed since the early 2010s.** Manufacturing's share of GDP at current prices peaked at around 31 percent in 2000 and fell to 21 percent in 2019 before recovering slightly during the COVID-19 pandemic. While manufacturing typically shrinks as economies develop, Malaysia's deindustrialization had occurred at a much lower level of income compared with developed economies' past experiences (Figure A3.3). This raises concern that Malaysia may not be able to reap the rewards of industrial-led productivity growth, which could reduce potential growth and its ability to advance to a high-income status. In fact, Malaysia has remained as a middle-income country for several

[99] Prepared by Wee Chian Koh.

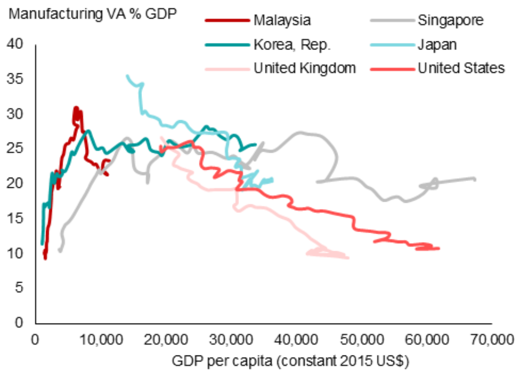
decades (Figure A3.4). The causes of premature deindustrialization are multi-faceted, but likely reflect China's rapid industrialization which resulted in a loss of competitiveness for Malaysia in many labor-intensive manufacturing industries, as well as slow progress in industrial upgrading to high-value added segments of the manufacturing value chain.

Figure A3.2. Shifts in Malaysia's Export Composition



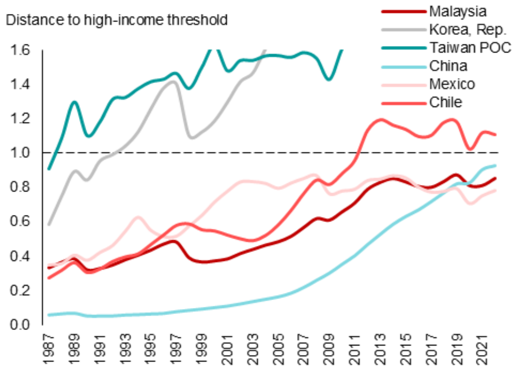
Source: Atlas of Economic Complexity

Figure A3.3. Manufacturing Share of GDP and Per Capita GDP



Source: World Bank; AMRO staff calculations

Figure A3.4. Distance to High-Income Status



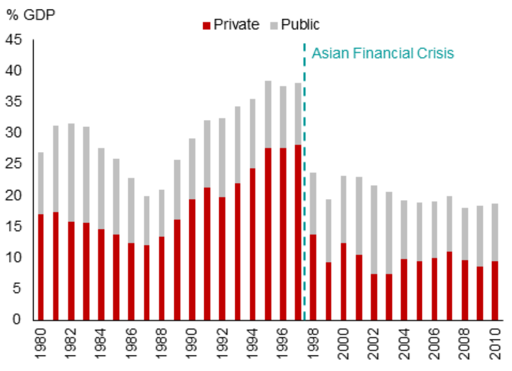
Source: CEIC; World Bank; AMRO staff calculations
Note: High-income threshold based on World Bank's country income classification that is adjusted annually.

3. **Hurdles to industrial upgrading include inadequate private investment, limited backward linkages, low spending on research and development (R&D), and a lack of skilled talent.** Private investment, including FDIs, has been the main engine of Malaysia's manufacturing expansion until the AFC, when it fell sharply from an average of 24 percent of GDP in 1990-1997 to less than 10 percent in 1998-2010 (Figure A3.5). At the same time, efforts to deepen manufacturing development have not succeeded in nurturing a critical mass of domestic firms capable of producing indigenous innovation; instead, industrialization continues to be dependent on imported capital and technology with limited backward linkages, especially in the E&E sector (Tham and Loke 2011). A culture that is lacking innovation is also reflected in the low level of R&D spending, number of researchers, and patents granted (Figure A3.6).[100] Moreover, R&D capital is dispersed across different and unrelated areas of research.[101] The skill shortages, persisting despite an increasing supply of new graduates from tertiary education institutions, pose a major concern.

[100] The number of U.S. patents granted to Malaysian entities is predictably low, with approvals received by multinational corporations that are largely associated with the semiconductor industry. Likewise, patents granted in Malaysia are mostly to foreign residents.
[101] In the private sector, R&D expenditure is mainly spent on automotive technology, electronic components, and consumer electronics. R&D outlays in government research institutes mostly go to agriculture-related areas and ICT applications. Meanwhile, R&D spending in universities is varied, ranging from biochemistry and engineering to education and communications, and mostly supports basic research aimed at journal publications rather than practical research that target commercialization.

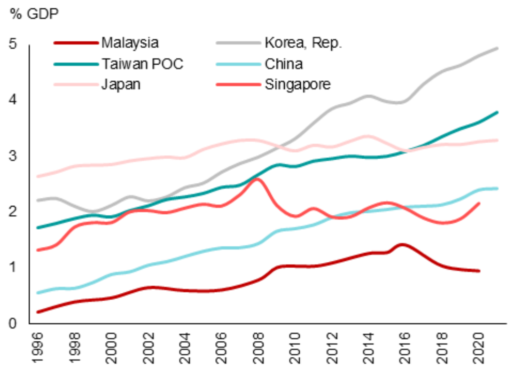
Importantly, the declining interest in science, technology, engineering, and mathematics (STEM) education among Malaysian students, low Program for International Student Assessment (PISA) scores, and high failure rates in the national exam for Mathematics subjects will add to future talent woes (Figures A3.7, A3.8).

Figure A3.5. Private and Public Investment



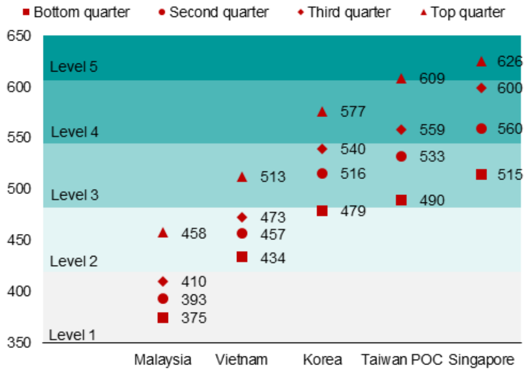
Source: Department of Statistics Malaysia (DOSM); AMRO staff calculations

Figure A3.6. R&D Spending



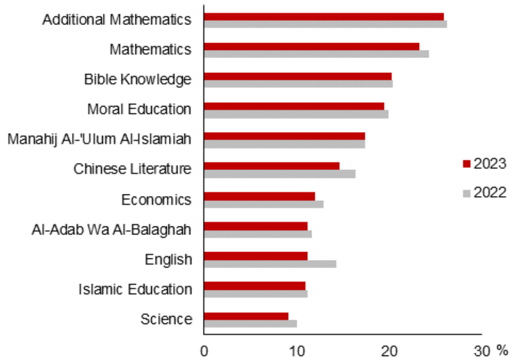
Source: CEIC, UNESCO Institute for Statistics; World Bank; AMRO staff calculations

Figure A3.7. PISA Mathematics Score by Socioeconomic Group



Source: OECD; AMRO staff calculations

Figure A3.8. Sijil Pelajaran Malaysia (SPM) Subject Failure Rate

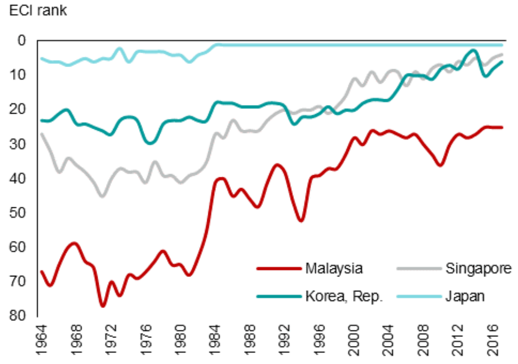


Source: Ministry of Education; AMRO staff calculations

4. **Cognizant of these challenges, the government has sought to reinvigorate the manufacturing sector through various industrial policies.** The latest instalment is the New Industrial Master Plan (NIMP) 2030 launched in September last year.[102] In line with its structural stagnation in manufacturing, Malaysia's global position in economic complexity has barely improved over the past two decades, after climbing rapidly from the 1960s to 2000 (Figure A3.9). A key mission of NIMP 2030 is therefore to advance economic complexity, that is, to innovate and produce more sophisticated products.[103] Specific attention is given to semiconductors, which have become the core pillar of the country's manufacturing sector. While the share of exports of machinery, office equipment, and telecommunications have either declined or stagnated, semiconductor exports surged from around 30 percent of total E&E exports in 2000 to 66 percent in 2023 (Figure A3.10). The government aims to further develop the semiconductor industry's capabilities by nurturing domestic firms in integrated circuit (IC) design to become global champions and by attracting a global semiconductor leader to establish wafer fabrication in Malaysia.

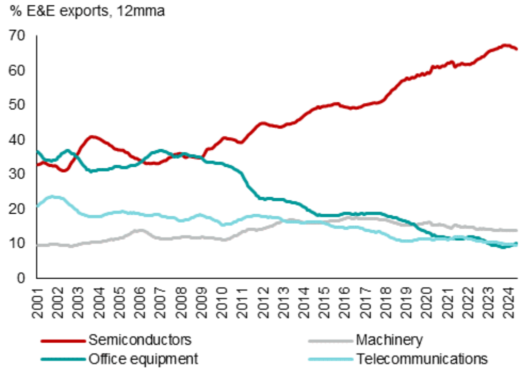
[102] Within seven years, NIMP 2030 aims to address some of the structural challenges by creating 700,000 high-skilled manufacturing jobs, raising median manufacturing monthly wages from under MYR2,000 to MYR4,500, increasing R&D expenditure from 1 percent to 3.5 percent, and doubling Malaysia's global market share in high-tech manufacturing exports to 6 percent.
[103] Economic complexity is a measure of the knowledge in a society embodied in its products. Countries that have sophisticated and unique capabilities and know-how can produce diverse and complex products that few other countries can make.

Figure A3.9. Economic Complexity Index Ranking



Source: Atlas of Economic Complexity

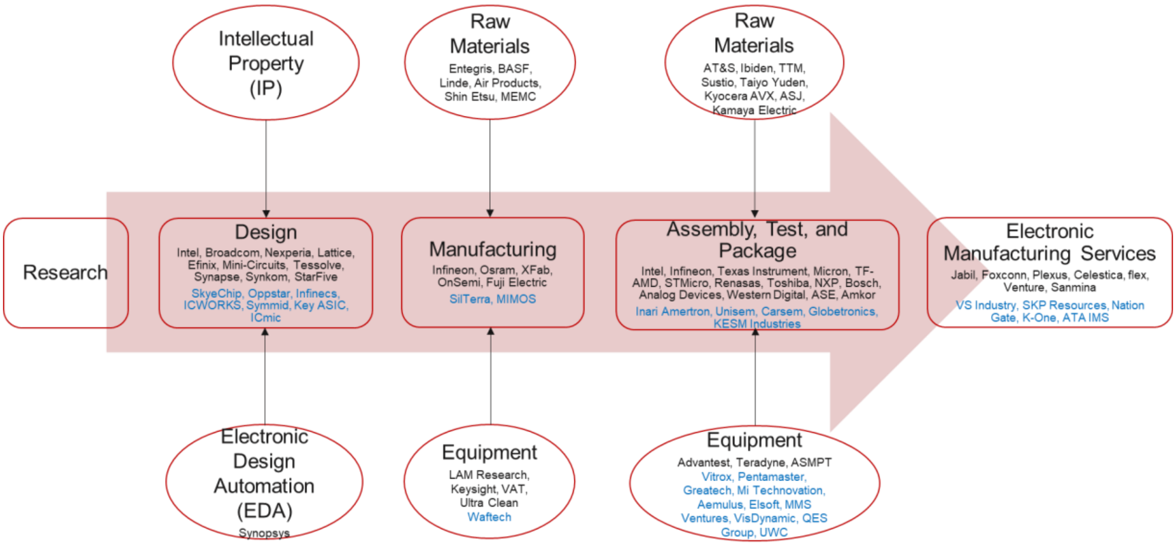
Figure A3.10. E&E Exports



Source: DOSM; AMRO staff calculations

5. **Malaysia has a relatively extensive semiconductor value chain, with a notable presence of local firms in design, OSAT, and ATE.** Semiconductor manufacturing involves three main processes: chip design, fabrication, and assembly, test, and packaging (ATP). Each of the processes has supporting value chains. Electronic design automation (EDA) software is used to design chips, while core intellectual property (IP) consists of reusable modular designs which allow design firms to license to others. The fabrication process is a complex and intricate series of steps that turns designs into chips, encompassing photolithography, deposition, doping, and etching, among others. Various manufacturing equipment and materials are used. ATP involves cutting a finished wafer into separate chips, mounting each chip on a frame with wires to connect it to external devices, enclosing it in a protective casing, and testing to ensure its operation. Figure A3.11 depicts Malaysia's semiconductor supply chain by identifying key foreign and local firms. Many multinational corporations have operations in Malaysia, but there is also a notable presence of local firms specializing in IC design, providing outsourced semiconductor assembly and test (OSAT) services, and supplying automated test equipment (ATE). However, there are relatively few firms in chip fabrication; fabs in Malaysia produce chips of older technology nodes. Firms specializing in R&D, EDA, and core IP are scarce as well.

Figure A3.11. Malaysia's Semiconductor Supply Chain



Source: InvestPenang; Malaysian Investment Development Authority (MIDA); Malaysia Semiconductor Industry Association (MSIA); AMRO staff's illustrations
Note: Firms are identified through industry contacts, desk research, and web searches, and are not exhaustive. Foreign firms are labelled in black and local firms in blue.

6. **To benchmark Malaysia's semiconductor industry and identify opportunities to strengthen its supply chain, we conducted a mapping of the global semiconductor value chain using detailed trade data.** The semiconductor supply chain is inherently complex with many interdependencies. As such, it is almost impossible to map the complete supply chain in detail from raw materials to finished product. Nonetheless, detailed trade statistics using Harmonized System (HS) codes at the six-digit level offer a good snapshot. Building on previous work by OECD (2019), we identified HS6 codes associated with key sub-processes in wafer production, chip fabrication, and ATP, including raw materials, inputs, and equipment. The results for exports are shown in Figure A3.12. A few caveats are in order. First, value chain steps such as R&D and design are not recorded in goods trade statistics. Second, some materials and equipment are captured under a broader category.[104] Third, the HS6 codes are not detailed enough to distinguish between frontier and mature technologies. Last, it is impossible to differentiate trade by domestic and foreign firms.

Figure A3.12. Export Mapping of Global Semiconductor Value Chain

Source: UN Comtrade; AMRO staff calculations
Note: CN = China; HK = Hong Kong, China; DE = Germany; IN = India; JP = Japan; KR = Korea; MY = Malaysia; NL = Netherlands; PH = the Philippines; SG = Singapore; TW = Taiwan, Province of China; TH = Thailand; UK = United Kingdom; US = United States of America; VN = Vietnam. Data for 2019-2022, normalized by product category. A darker shade represents a larger share of global exports.

7. **Malaysia has a significant share of global exports only in final semiconductor output, certain manufacturing equipment, and high-purity silicon.** In terms of materials used in wafer and chip fabrication, Germany and the U.S. have high market shares in high-purity silicon. China dominates in raw materials, such as germanium and silicon carbide.

[104] For instance, photomasks are included in a category of photographic plates and film (HS 370130). Similarly, germanium is under a combined category for germanium and zirconium (HS 284920). Certain semiconductor equipment used in fabrication and ATP is classified together under machines and apparatus for the manufacture of semiconductor devices or ICs (HS 848620).

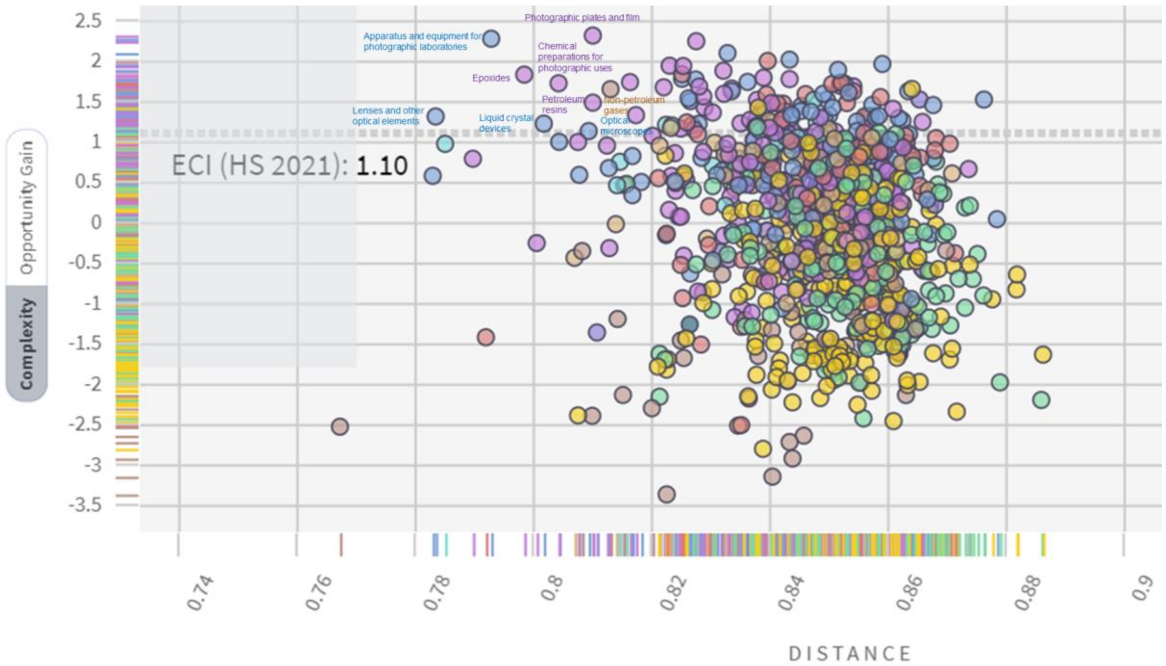
Japan and China, and to some extent Germany, the U.S., and Korea, are key exporters of silicon wafers, electronic gases, and wet chemicals.[105] Japan is the market leader in the production of photoresists.[106] Japan, the Netherlands, and the U.S. dominate in certain equipment, with Malaysia and Singapore also commanding respectable shares.[107] Packaging materials are mostly exported by China, Germany, Japan, and Taiwan POC. Despite the strong U.S. presence in most parts of the supply chain, the U.S. exports only a small share of global chip production. Instead, the bulk of exports are from Taiwan POC and China, including Hong Kong.[108] Malaysia's share of global chip exports is around 6 percent, the sixth largest globally. However, Malaysia imports a large proportion of intermediate inputs. In fact, other than high-purity silicon and certain manufacturing equipment, Malaysia is a net importer of all other fab and packaging materials, components, and equipment. This suggests ample opportunities for Malaysia to strengthen its supply chains, and hence forms a basis for a more targeted national semiconductor strategy.

8. **Malaysia has high potential to advance economic complexity in organic chemicals and optical apparatus, which can also strengthen its semiconductor supply chain.** The new product opportunities that can raise Malaysia's economic complexity and require related capabilities and know-how of existing products are mostly in the chemicals and machinery sectors (Figure A3.13). Potential new products include photographic plates and film, lenses and optical elements, optical apparatus and equipment, microscopes, epoxides, lubricants, and other chemical compounds. The possibility of diversifying into these low-hanging fruits bodes well for the semiconductor industry, since most of these inputs are now sourced from abroad.

9. **In addition to the potential opportunities identified in NIMP 2030 and the product space, there are new and emerging technologies that Malaysia can further tap into.** Next-generation power electronics will be based on compound semiconductor materials, such as SiC and gallium nitride (GaN), due to their significantly higher energy efficiency than normal silicon (McKinsey 2023). Infineon is investing EUR5 billion to build the world's largest 200-millimeter SiC power fab in Kulim to meet the rising demand for power semiconductors used in electric vehicles, data centers, and renewable energy. Advanced packaging allows multiple chips and components to be placed closer together, resulting in enhanced performance and functionality (BCG 2024). Leading chipmakers and OSAT firms are investing in new facilities to meet the growing demand for advanced packaging. Intel is investing USD7 billion to build its first overseas facility for advanced 3D chip packaging in Penang. Likewise, ASE, the world's largest OSAT company, is building its fourth and fifth assembly and test facilities in Penang. Packaging innovations can also create opportunities for other players in the value chain, such as ATE manufacturers and suppliers of materials and components. Although still at an infancy stage, graphene is touted as a potential game changer for semiconductors due to its exceptional properties, such as high flexibility, strength, and physical and chemical stability, making it suitable for a wide range of applications (McKinsey 2018). Graphjet Technology, headquartered in Kuala Lumpur and listed on NASDAQ, aims to be a global leader in supplying low-cost graphite and graphene for semiconductors and EV batteries.

[105] However, China has limited capabilities in producing high-tech (300mm) wafers. Leading firms in wafer production are Shin-Etsu and SUMCO (Japan), Siltronic (Germany), and SK Siltron (Korea). Firms in electronic gases are Merck and Linde (Germany), Entegris and Air Products (U.S.), and Showa Denka (Japan). Firms in wet chemicals include BASF (Germany), KMG Chemicals and Honeywell (U.S.), and Runma and JHM (China).
[106] Leading Japanese firms are JSR, Tokyo Ohka Kogyo, Shin-Etsu, and Fujifilm Electronic Materials.
[107] Leading firms include ASML (Netherlands), Canon, Nikon, Tokyo Electron, and Advantest (Japan), Applied Materials, KLA, Lam Research, and Teradyne (U.S.). Some of these MNCs have production facilities in Malaysia and Singapore.
[108] China's chip production is largely based on matured process node technologies, led by SMIC and Hua Hong. Advanced logic chips are mainly manufactured in Taiwan POC by TSMC and advanced memory chips in Korea by Samsung and SK Hynix.

Figure A3.13. Malaysia's Potential Growth Opportunities



Source: Atlas of Economic Complexity
Note: Distance is a measure of the ability to enter a specific product. A shorter distance can be interpreted as lower risk, since the new product requires related existing capabilities and know-how. The identified new products on the upper left have relatively shorter distances and higher economic complexity than the current average.

10. Looking forward, policymakers should continue to keep abreast of technological developments and carve out a long-term strategy for future economic leaps. Malaysia's economic foresight to proactively court global semiconductor players to relocate in Penang in the early 1970s has shaped the country's industrial structure and produced immense economic benefits. Thanks to its well-established E&E manufacturing ecosystem, Malaysia's semiconductor industry is now experiencing renewed investment interest due to the reconfiguration of the global chip supply chain amid increasing U.S.-China trade and technology tensions. Beyond chip design and fabrication, policymakers can consider adding the identified opportunities from Malaysia's semiconductor value chain mapping and next-generation technologies into the National Semiconductor Strategy (NSS) unveiled in May this year. Above all, addressing the structural impediments to industrial upgrading, especially skill shortages and limited R&D spending and industry-academia collaboration, is vital in positioning Malaysia as an important semiconductor hub and reviving its status as the Silicon Valley of the East.

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