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SEMICONDUCTOR NATIONALISM AND ITS IMPLICATIONS FOR MALAYSIA

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EXECUTIVE SUMMARY

- Semiconductors have been heralded as the "new oil", taking centre stage in the trade war between the USA and China today.
- "Semiconductor nationalism" is the newly coined phrase to describe the wave of industrial policies, trade protectionism and foreign policy practised by countries to protect their domestic semiconductor industries, the domestic companies in the sector receiving preferential treatment and importance over other sectors.
- Through studying the experience of a few *comparator territories* - USA, Japan, China, Taiwan and South Korea - we find that semiconductor nationalism is not new and was a key factor underpinning their emergence to become semiconductor global powers today.
- From the experience of the five *comparator territories*, we develop a three factor framework that highlights the main underlying factors for their success: **a window of opportunity, semiconductor nationalism and the right agents.** Semiconductor nationalism has been shown to be a necessary factor, aided by a window of opportunity and/or the right agents.
- A window of opportunity certainly exists today for Malaysia to realise its ambitions however the verdict is not clear whether the Malaysian government is prepared for the large commitments that are required.
- The experience of the *comparator territories* provides many models for Malaysia to consider and this discussion paper provides a framework as a basis for devising the policies that are required to take Malaysia forward in the semiconductor value chain.

Table 1: Summary of implications for Malaysia

Key elements of semiconductor nationalism	Detail
Recognition of importance	• A crucial shift in mindset in the public and private sector towards prioritizing national outcomes is required to follow through on the NSS
Technology acquisition	• The nascent advanced packaging technology provides an opportunity for technology co-development and catch-up • Malaysia should be strategic in its appropriation (which technologies to acquire) • Focus on applied research projects and build on advantage in manufacturing • A coherent strategy is required on how the technologies should be acquired

EXECUTIVE SUMMARY

Key elements of semiconductor nationalism	Detail
Protectionist policies	• Whether Malaysia should protect its domestic semiconductor companies from uncompetitive behaviour of global agents • A cost benefit analysis should be taken in the case of uncompetitive pricing of products that are also inputs for other sectors • Various policy tools are available - do nothing, place tariffs, enact quotas, procurement policy etc - and the pros and cons of each carefully weighed • Resource competition from FDI is another source of concern, Malaysia needs to identify priority sectors that need protection • A good IP regime can be a double-edged sword, Malaysia needs to craft a nuanced one that serves its needs holistically
Development policies	• Malaysia needs to improve its R&D ecosystem and provide consistent and increased funding, improving its R&D share of GDP • A localisation and government procurement policy is crucial, but tailored to sector maturity • Industrial policy needs to be balanced with ensuring competitiveness remains • Export oriented incentives is another tool that can be considered in a targeted manner • Supply chain resilience consisting of the development of local players and close proximity of suppliers and customers should be the focus of the development strategy
Foreign policy	• Semiconductor diplomacy is the “phrase du jour” • Malaysia should leverage its neutral position, mature ecosystem and semiconductor manufacturing know-how to negotiate for the areas that it lacks, such as capital, technology and key talent
Capital	• Malaysia’s fiscal bullets should be deployed very strategically as part of a holistic semiconductor nationalism strategy in order to be most effective • A main objective of fiscal incentives is to build companies with strong global market shares and large and consistent cash flows to enable them to entrench themselves in high value markets and R&D activities • These companies should in turn be tasked to develop their supply chain locally in Malaysia and spearhead technological development • Chaebol model of South Korea is being adopted by India and Thailand, is it an option for Malaysia? • Will Malaysia commit to initiatives that are costly and have long gestation periods, in a highly cyclical sector? • Direct government intervention into companies (state entrepreneurial model) has not been successful, Malaysia should avoid picking winners - instead, work on building an ecosystem that incentivises competitive players to emerge

Source: REFSA analysis

GLOSSARY OF TERMS

CHIPs Act *Creating Helpful Incentives to Produce Semiconductors and Science Act, an instrument of US industrial policy for its semiconductor sector*

Compound semiconductor *Semiconductors that are made from two or more elements, unlike the currently widely used silicon wafers that are only made out of silicon*

C-MOS *A technology used for constructing semiconductors that produces less heat*

CSIS Center for Strategic and International Studies, an American think tank

DARPA *Defense Advanced Research Projects Agency, a US agency*

DRAM *Dynamic random access memory, a memory chip used in computing and mobile devices*

EDA *Electronic design automation, describes the softwares that are used to design semiconductors*

ERSO *Electronics Research and Service Organization, a subsidiary of ITRI that focuses on semiconductor product research*

ETRI *Electronics and Telecommunications Research Institute of South Korea*

Fab *Short for "fabrication plant" to mean a semiconductor manufacturing facility*

FDI *Foreign direct investment*

FILP *Fiscal investment and loan program, an off-budget non bank financing arm of Japan*

IC *Integrated circuit, synonymous with "chip" and "semiconductor"*

ICT *Information communication technology*

IDAR *Introduction, digestion, assimilation and re-innovation, China's technology acquisition strategy between 2006-2020*

IDM *Integrated device manufacturer, a company that designs and manufactures its own chips in-house, e.g. Intel and Samsung*

IMF *International monetary fund*

IP *Intellectual property*

ITRI *Industrial technology research institute, Taiwan*

KIAS *Korea Institute for Advanced Study*

GLOSSARY OF TERMS

KIET *Korea Institute for Industrial Economics and Trade*

KIST *Korea Institute for Science and Technology*

JV *Joint venture*

LSTC *Leading edge semiconductor technology center, Japan's technology research association*

MITI *Ministry of Trade and Industry, Japan*

MIMOS *Malaysian Institute of Microelectronic Systems, an applied research and development center*

MNC *Multinational companies*

NIMP 2030 *New Industrial Master Plan 2030, Malaysia*

NSS *National semiconductor strategy, Malaysia*

OECD *The Organisation for economic co-operation and development*

OEM *Original equipment manufacturer, represents companies that provide outsourced manufacturing services*

OSAT *Outsourced semiconductor assembly and test*

R&D *Research and development*

SIA *Semiconductor Industry Association, US*

SOE *State-owned enterprises, China*

UNIDO *United Nations Industrial Development Organization*

USM *University Science Malaysia*

VLSI *Very large scale integration, the process of creating a semiconductor by combining millions or billions of transistors onto a single chip.*

WTO *World trade organization*

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1.0 Introduction

Semiconductors have become an indispensable key component underpinning the technologies that will grow to define our modern lives - from the AI revolution to the global effort to decarbonise. Without semiconductor development such technologies are rendered obsolete. From energy, mobility and security to manufacturing, computing, entertainment and shopping, developed societies are moving towards an era where the microchip will power almost every facet of the modern economy. However the industry is undergoing seismic global supply chain reorganisation, the rise of protectionist policies and trade barriers, as well as massive subsidies and support for respective domestic players. Global capital flows and economic activity is currently being defined by supply chain resilience, foreign policy and national security concerns, giving rise to the term “semiconductor nationalism”. The recent re-election of Donald Trump will accelerate the bifurcation of supply chains, especially for semiconductors, that are deemed crucial for the US’s national security interests.

This paper attempts to explore the development of the semiconductor industry using the lens of “semiconductor nationalism” in a few key territories by virtue of their position in the global chip supply chain today: USA, Japan, China, Taiwan and South Korea (hereafter referred to as the *comparator territories*). In doing so we illustrate that semiconductor nationalism is not new but has been used repeatedly by various countries at opportune times in order to further their own agendas. Chapter 2 begins by defining “semiconductor nationalism”, and then illustrates the interconnected supply chain we have today. Chapters 3 to 7 goes on to show that these *comparator territories* have each pursued their own version of semiconductor nationalism in the history of their development. It is the effort of these territories towards furthering their own national agendas that has come to shape the global semiconductor supply chain footprint we have today.

Chapter 8 gives the reader a brief understanding of the semiconductor industry in Malaysia and how it also tried to move up into the chip fabrication space but failed. The discussion culminates in Chapter 9 with lessons learned and how these can be applied to Malaysia. We take in lessons on how the US-Japan post-war relations shaped Japan’s rise in semiconductors, how the US-Japan Chip war in the 1980s opened up a window of opportunity for South Korea to enter the market, and how China’s ascension to the World Trade Organisation (WTO) was pivotal to its own semiconductor growth. China’s rising dominance also presented a dilemma to Taiwanese policymakers who seemingly had a conflicting choice between supporting its tech companies and national security.

We show how the success of a nation’s semiconductor industry often required three key factors. The first being a lowering of barriers to entry, the second being a government that pursues semiconductor nationalism and the third being having the right agents to execute the plans and policies effectively. We apply this framework to the context of the US-China Chip war today and analyse its implications for Malaysia. We conclude that while one of the three conditions are there for Malaysia, the other two need to be strengthened in order for Malaysia to successfully capture this window of opportunity to firmly establish itself as a higher value player in the semiconductor industry.

The terms integrated circuits (IC), chips and semiconductors are used interchangeably.

2.0 The Semiconductor Supply Chain is a result of Semiconductor Nationalism

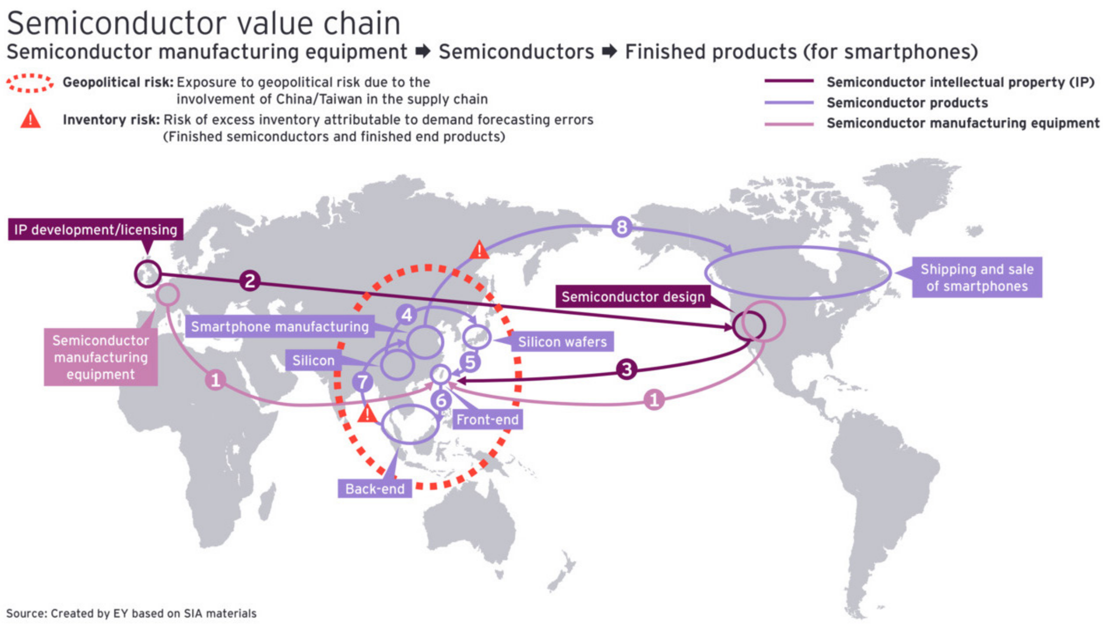
We first begin by defining semiconductor nationalism and how it is distinct from industrial policy. Industrial policy promotes the industrial development of certain sectors of the economy, and semiconductor manufacturing can be one of many other sectors targeted such as steel and automotives. However here we characterise semiconductor nationalism as having two additional elements, the first being a focus on developing national champions in the form of domestic companies. The second is the use of means additional to industrial policy. Instead of merely being a preferred sector in industrial policy, semiconductor nationalism is where governments go a step beyond, giving domestic players in a particular sector more importance and preference compared to other parts of the economy. Semiconductors become the focal point around which other policies revolve around, and sometimes amended to give preference to, such as industrial policy, competition policy, education, intellectual property (IP), immigration, foreign relations, trade and investment. Today, this is more apparent than ever, becoming an important agenda in geopolitics.

In the following discussion, we see how territories have utilised various tools in order to establish, promote, develop and protect their domestic semiconductor industry players. The investigations are not meant to give an exhaustive account but rather to highlight what we believe are the key milestones that aided in the development of the territory's semiconductor industry. Territories who pursued such industrial policy agendas recognised early on the importance of the electrical and electronics industries as a means of employment, technological advancement and economic development, contributing to political capital. Tactics and strategies are deployed in areas such as IP protection, trade and non trade barriers, FDI regulations, tax incentives, grants, market access, education, foreign policy etc in support of the domestic IC industry. In chapters 3-7, by following the evolution of semiconductor development in key territories, we lay the argument that today's global semiconductor value chains are precisely the result of such semiconductor nationalism strategies that promoted the development of highly specialised companies and technologies that form the backbone of today's electronics industry.

The semiconductor industry is truly a poster child for global capitalism, and its principle of comparative advantage and Pareto optimisation, characterised by economies of scale and economies of scope. Put simply Pareto optimisation states that each country should produce those goods at which they can manufacture most efficiently, and then trade with other countries for other goods that they do not have a comparative advantage in. Such specialisation and subsequent trade in goods and services would result in the most optimal outcomes for all such as lower prices and better quality products. This is the theory that has underpinned the framework for global trade liberalisation and the WTO.

For semiconductors, the world came to be carved out precisely this way through ecosystem and technology development. The complex global value chain that exists today evolved from a simple function of knowledge, talent, capital and costs. These four key ingredients were engineered by companies, research institutions and governments into respective specialisations in different parts of the semiconductor value chain. The focused expertise we see today in the industry is what has enabled semiconductor development to move forward in breakneck speed of Moore's law - the number of transistors on a single chip doubling every two years, i.e. the computing power of chips rising exponentially every two years.

Figure 1: A simple representation of today's global semiconductor value chain

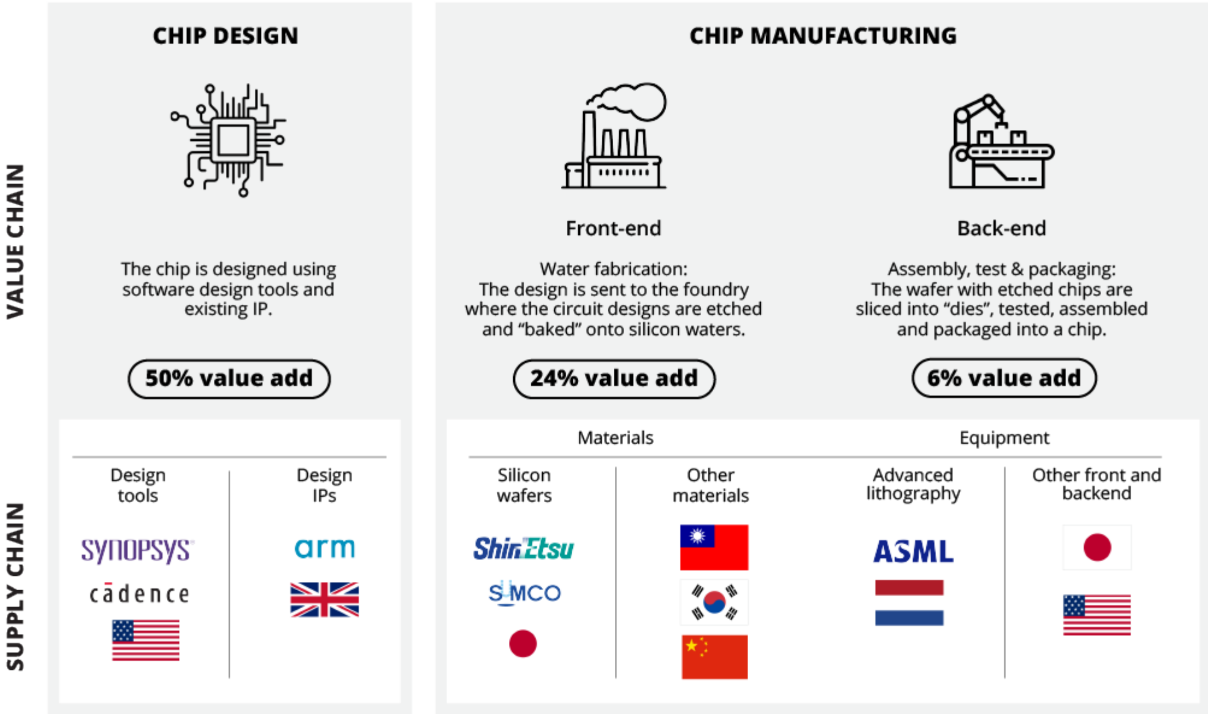


Source: EY, The future of semiconductor procurement - The changing semiconductor supply chain

For a more detailed explanation of the semiconductor supply chain, please see Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region from CSIS. The gist is that semiconductor chip design is dominated by companies from two countries - the IP provided by Arm Holdings Plc (Arm) from the UK for mobile devices and chips designed by US fabless and IDM[1] companies. The chips are then manufactured in many of the *comparator territories*[2], with a significant presence in the assembly, test and packaging portions in China and South East Asia. The market for wafer fabrication materials is dominated by the *comparator territories*, while semiconductor equipment manufacturers are dominated mainly by the USA and Japan. It is worth noting that Advanced Semiconductor Materials Lithography (ASML), a company based in the Netherlands, is the only supplier of high-end lithography machines, a crucial piece of equipment for the production of advanced chips. Figure 2 illustrates the steps in the production chain, together with the corresponding value adds of each segment. This is followed by the supply chain that supports each production step with the largest players in each, where there are many players, the dominant countries are shown.

1. "Fabs" are short for wafer fabrication plants, and fabless chip designers mean that these companies produce these chips by designing them and then outsourcing their actual manufacture to a "foundry" or "fab" company. "Foundries" and "Fabs" can be pure-play as in the case of TSMC, who only manufacture but don't design chips, or part of the facilities of an "integrated device manufacturer" (IDM) which is essentially a firm that both designs and manufactures its own chips in-house.
2. Thadani A, Allen G C, Center for Strategic and International Studies (CSIS), May 2023, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region

Figure 2: Steps in the production value chain with the respective value adds and main supply chain players



Source: REFSA research, value add data from Exhibit 4, Strengthening the Global Semiconductor Supply Chain in an Uncertain Era

The concentrated and specialised nature of semiconductor value chains arose not just out of selfish commercial interests of economic agents, but also through periods of collusion between companies, tactics to build barriers to entry, and government directed domestic and geopolitical concerns. Many of the advances were a result of individual profit maximisation activities and collaborative efforts of firms working together under government support, at other times directed under deliberate government agendas. This is true for almost all the key players in the semiconductor space today; the top semiconductor countries can attribute some of their success or origins to key interventions or concerted efforts involving heavy intervention from the state.

3.0 Semiconductor nationalism in the USA

While the CHIPs Act provides the most recent example of semiconductor nationalism in the US, there have actually been many instances in the past where US foreign policy has been guided by economic and security concerns. This can be seen both domestically and in the international arena where geopolitics, national security and technology have historically been closely intertwined. In the 1950s and 1970s, US foreign policy towards China was based on containment[3], with the strategy to form a military alliance of economically strong and developed countries surrounding China. This strategy meant that the economies of Japan, Taiwan and South Korea benefited from development aid grants, technology transfers and military assistance through the Foreign Assistance Act, Mutual Security Act, and Act for International Development passed by the US congress.

Table 2: Timeline of US government key interventions in the semiconductor industry

Year	Policy / government actions	Detail
1950s-1960s	Cold War R&D for defence	Heavy investment into semiconductor research benefitted companies such as Fairchild Semiconductor and Texas Instruments
1976	DARPA support on miniaturisation	DARPA commissioned a report on the future of miniaturisation and provided funding for solutions to the problem. This catalysed the creation of chip design software tools
Late 1970s	US-Japan semiconductor trade war	US reacted to competition from Japanese DRAM makers by increasing its R&D support, the use of tariffs and coercive tactics
1986	US-Japan semiconductor agreement	Japan agreed to increase the price of its semiconductors and to open up 20% of its domestic market to foreign producers within 5 years[4] among other measures
1987	Creation of Sematech	A collaborative research institute funded by the US government, modelled after Japan's VLSI project
1991	Renegotiation of the 1986 agreement	The anti-dumping measures of the 1986 agreement were opposed and renegotiated
2022	US Chips act	A policy with USD59bn worth of incentives aimed mainly at attracting chip manufacturing back to US shores and to secure its supply chain in advanced chipmaking

Source: REFSA reseach

3. Asia for Educators Columbia University, U.S.-China Relations Since 1949
4. Irwin, D A, 1996, The Political Economy of Trade Protection, The US-Japan Semiconductor Trade conflict

Back home, the semiconductor industry really started with US research into defence technologies, especially during the Cold War, to maintain technological superiority over the Soviet Union. In order to build better rockets and to boost military capabilities, the US government was "buying nearly every integrated circuit produced in 1962, half by 1966 and still 40 percent by 1968"[5]. The semiconductor companies Texas Instruments and Fairchild Semiconductor flourished by the 1960s from these contracts and developed further when they were able to find civilian uses for the ICs they were developing for the defence industry. Large strides in manufacturing advances were made, which allowed them to slash chip prices and penetrate the consumer market.

Government support declined in the 1970s as more semiconductor companies such as Intel and IBM joined the industry and grew in strength. In 1976, the Defense Advanced Research Projects Agency (DARPA), a R&D agency of the United States of Department of Defense, commissioned a report on exploring the challenges to future miniaturisation of semiconductors which found that there were six limitations, two of which they identified could be resolved by the private sector on their own. The report recommended a budget of USD500k to look into how the government could address the four other challenges. One of these dilemmas was how to design chips more efficiently, which sparked DARPA funding to canvas for innovative ideas from research labs and academia. This government intervention into a potential market failure where the private sector would not fund due to risk-reward considerations, enabled the development of chip design software, a technology that the US still dominates up to this day, in the form of Cadence and Synopsys, two US electronic design automation (EDA) tools companies that hold 30-35% market share.

By the late 1970s, the US was facing stiff competition from Japanese dynamic random access memory (DRAM) producers. Buoyed by Japan's semiconductor industrial policies, Japanese producers overtook their US counterparts to produce chips that were not only cheaper but also an immensely lower defect rate. The Japanese also had access to vast sources of cheap capital, an unfair advantage in the heavy capex world of chip fabrication plants. US market share in DRAMs plummeted from 70% to 20% between 1978 and 1986[2]. Amidst mounting pressure from US firms such as Micron and Texas Instruments, an agreement was reached with Japan, aimed to counteract perceived unfair trade practices and to protect the U.S. players. This however had an effect of increasing DRAM prices to such an extent that computer manufacturers - the main purchasers of DRAM - got together to oppose the 1986 agreement and cause it to be renegotiated in 1991. In the end only the provision of requiring Japan to open up 20% of its market to foreign ICs remained.

1987 marked the US's final attempt (before today) to intervene in its semiconductor industry with the establishment of Semiconductor Manufacturing Technology, or Sematech. The brainchild of the US Semiconductor Industry Association (SIA) and modelled after Japan's VLSI project (see Chapter 4), Sematech was a public-private collaborative research effort to develop US's domestic equipment making knowhow. Funded to the tune of USD500mn over a five year period, the project initially involved 14 private companies to co-fund and participate in the research project, including the largest US chipmakers at that time. This was in response to Japan's dominance in the semiconductor equipment space. While opinions differ on whether

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5. Miller C, Center for a New American Security (CNAS) Report, 2022, Rewire - Semiconductors and the US industrial policy

Sematech achieved its goals, it has grown to become an important and popular case study on the effectiveness of public-private research consortiums[6].

Besides Sematech, the government stayed out of the market for much of the 1990s and pursued the policy of globalisation which meant that much of US manufacturing hollowed out particularly to China. Many of the interventions meant to protect US incumbents in the DRAM space from the US-Japan 1986 agreement did little to shield them from the innovation and ingenuity of South Korean firms that emerged as strong contenders due to the market vacuum left by the Japanese players from the US-Japan chip war. Despite the interventions, all other US DRAM producers exited the market leaving Micron as the sole US DRAM player, which many argue is due to its success in innovation and efficiency. This is frequently cited as an argument against government protectionist industrial policies[7].

Due to its leadership in R&D supported by world-leading academic institutions, and its stronghold in the chip design ecosystem, the US remains one of the key players in the semiconductor industry today[8]. Its semiconductor industry association reported a 50% share of global sales revenue in 2023 and that the US has maintained this position since the 1990s. This strength contributes to a strong balance sheet and provides US companies with a cash pile that they pour heavily into R&D activities. Hence the US is also the leader in semiconductor R&D, design and manufacturing process technologies[9]. These large R&D activities in turn act as market barriers that entrench their dominance in the product and innovation space, allowing them to maintain their market share in global sales.

In recent years, semiconductor nationalism became the centre of geopolitics yet again with the arrival of Donald Trump to the White House in 2017, on the back of the promise to "Make America Great Again". Industrial policies are now back in fashion, especially after the COVID-19 lockdowns that woke the world up to the vulnerability of semiconductor supply chains. This provided the catalyst that tipped US policy toward China from a "brewing tensions" situation into an outright trade war. Concerns over China's rising technological capabilities in semiconductors culminated in the CHIPs for America Act under the Biden administration. Its main objectives are securing supply chain resiliency and protecting national security by bringing the production of microchips back to US shores. Provisions in the act as well as other supporting policies limit China's ability to access advanced semiconductors, as well as the means to produce them.

Sitting at the heart of the semiconductor nationalism issue are a couple of key companies which are Taiwan Semiconductor Manufacturing Corporation (TSMC) from Taiwan, the maker of 90% of the world's advanced chips, NVIDIA from the US, the company that designs these chips as well as ASML from the Netherlands, the only provider of high end lithography equipment that enables these chips to be produced. These key companies as well as others have been coerced to prevent China from accessing advanced chip technologies. Synopsys and Cadence have also been prohibited from providing China access to the tools required to design high-tech chips.

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6. Wessner C, Howell T, CSIS, 2023, Implementing the CHIPS Act: Sematech's Lessons for the National Semiconductor Technology Center
7. Miller C, Center for a New American Security (CNAS) Report, 2022, Rewire - Semiconductors and the US industrial policy
8. Thadani A, Allen G C, CSIS, 2023, Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region
9. Semiconductor Industry Association SIA 2024 state of the US semiconductor Industry Report

Table 3: Elements of US semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
US			●		●	●	●

Source: REFSA research

Here we can see that the US semiconductor industry and its nationalism developed from national security objectives. Our discussion did not observe any particular window of opportunity that enabled its domestic industry to leap forward. Its advancements were the result of its own innovation and efforts in R&D. It was semiconductor nationalism that enabled the development of its spearheading agents - companies such as Texas Instruments and Fairchild semiconductor - through the support provided by government procurement projects in the 1950s and 60s. The economic agents that really led the foray came in the form of its firms as well as its talented workforce, which consisted not only of American citizens but many immigrants as well[10]. The American model was built on the success of the strong R&D culture of its firms, through the agglomeration effects of tech firms, academia and capital within Silicon Valley. Hence while most of the R&D in semiconductors was spearheaded directly by the firms themselves, these advances could not have been made without its academic and research institutions' advances in basic research as well as in developing a robust ecosystem for generating talent.

10. Bernstein S et. al, 2022, The Contribution of High-Skilled Immigrants to Innovation in the United States

4.0 Semiconductor nationalism in Japan

The development of Japan's semiconductor industry was closely tied to that of its main patron, the USA. Post World War II, US policies were aimed at helping Japan develop its economic potential, mostly to serve as a bulwark to China in the context of the Cold War. Japan, with its economy in tatters, began to divert its full resources and attention towards rebuilding the country and subsequently towards manufacturing and technological advancement. The Japanese tech industry benefited from technology transfers from the US as part of its foreign policy in the Far East. The Japanese tech industry managed not only to catch up with its American "teachers" but also grew to challenge the market dominance of American companies especially in the market for DRAMs, a type of memory chip which is ubiquitous in all computers and computing devices.

The US-Japan relationship post-war was not an easy one. During the Korean war in the 1950s, the USA attempted to support the Japanese economy by procuring much of its supplies from Japan. Although Japan had managed to restructure and rebuild its economy through this help, it grew increasingly frustrated by its economic reliance on and lop-sided security arrangements with the US. In an attempt to diversify its economic and political relationships, in 1956 and 1957 Japan's Prime Ministers sought to formally normalise the country's ties with the Soviet Union and also started to pivot towards China. This was not in line with US foreign policy strategy of building friendly or allied buffer countries around China. In order to woo Japan back as an ally, US policymakers began to shift their approach towards strengthening Japan's economy as a key policy goal[11]. And thus began the programme for large scale US intervention and support to develop Japan through technology transfers, opening up of export markets and funding in the form of low interest loans via the World Bank.

Post World War II, there were several established keiretsu in Japan - such as Hitachi, Toshiba and Fujitsu - with businesses ranging from heavy industry, power and telecommunications to personal computers and consumer electronics. The creation of the Ministry of International Trade and Industry in 1949 cemented Japan's commitment towards industrial development[12] and electronics, by designating semiconductors as a strategically important sector for Japan with corresponding policies to support and protect it. 1953, the Fiscal Investment and Loan Programme (FILP), an off-budget financing arm that was funded by non-bank savings of the populace, was established. It has been partly used to finance the development of Japan's electronics industry over the years since its establishment[13]. MITI and FILP were crucial to the early development of Japanese tech companies. It was also during this period that electronic companies such as Sony managed to licence technologies from US companies.

In an effort to improve its efforts to cultivate Japan as an ally, the Treaty of Mutual Cooperation and Security was signed in 1960 between Japan and the USA. An article of the treaty mentions improving economic collaboration between parties[14]. However, while American companies tried to enter Japanese markets in the 1960s upon the signing of the Treaty, Japan employed

11. Beckley et al, 2018, America's Role in the making of Japan's economic miracle
12. Economics Online, 2024, MITI and the Economic Development Miracle of Japan
13. Ministry of Finance, Japan, Japan's Fiscal and Investment Loan programme
14. Ministry of Foreign Affairs, Japan, Japan US security Treaty

certain tactics to protect its incumbent firms. One of them was to delay the processing of IP applications of foreign companies as well as the approval of FDI into its markets. One such example was Texas Instruments' (TI) 14 IP applications in 1964 which were not approved until 1977, with final approval for all 14 only occurring in the late 1980s. This tactic bought ample time for Japan's domestic producers to replicate TIs products and technologies without incurring IP infringement fines and laws[15]. Another such example was delaying the approval for TI for the setting up of a wholly-owned subsidiary in Japan, coercing it to sign a JV agreement with Sony instead.

Table 4: Timeline of Japanese government key interventions in the semiconductor industry

Year	Policy / government actions	Detail
1949	Creation of MITI	The creation of the Ministry of International Trade and Industry that orchestrated Japan's dominance in semiconductors
1953	Establishment of FILP	The Fiscal Investment and Loan Programme financed many semiconductor industry projects
1960	Treaty of Mutual Cooperation and Security	US policy to aid Japan's economic development was somewhat formalised
1976-1980	Very large scale integration (VLSI) project	Historic and successful collaboration between Japan's domestic electronics firms on a government research project
1986	US-Japan semiconductor agreement	Anti-dumping and domestic market liberalisation measures to counteract perceived unfair Japanese trade practices
1990s-2000s	Various government directed initiatives	Various efforts to revitalise Japan's semiconductor manufacturing capability such as Hinomaru Foundry, the ASKA project and the MIRAI project
2021	Semiconductor revitalisation strategy	USD27.5bn allocated to focus on cutting-edge semiconductor technologies
2021	Japan Advanced Semiconductor Manuf'g	Establishment of a chip manufacturer between TSMC, Sony and Denso
2022	Leading-edge Semiconductor Technology Center (LSTC)	Establishment of the LSTC by the Ministry of Economy, Trade and Industry to develop a domestic semiconductor industry ecosystem

15. U.S. Congress, Office of Technology Assessment, 1991, Competing Economies: America, Europe, and the Pacific Rim, Ch 6 Japanese Industrial Policy: The Postwar Record and the Case of Supercomputers

Year	Policy / government actions	Detail
2022	Rapidus	Establishment of an advanced semiconductor manufacturing company with the goal to achieve the 2nm process by 2027
2023	Extra budgetary support	Japan approved USD13bn to return chipmaking onshore

Source: REFSA reseach

The VLSI project in 1976 was a historic collaboration between Japan's domestic electronics firms on a government project. It was the first such research consortium that involved competing tech firms working together on a joint-research project. The participating firms went on to become Japan's DRAM market champions in the 1980s such as Toshiba, Fujitsu and NEC. These companies had significant businesses in consumer electronics, so semiconductors was a natural step for them to develop a key component of their products. USD288mn was spent over four years of which 43% was provided as interest free loans from the Japanese government. The objective was to give its companies an early start in IC R&D and to reduce duplication of R&D efforts among each other. One of the successes was the catch-up of Japanese technology to American DRAM capabilities as well as other projects that yielded commercial results[16].

By the early 1980s, Japan had emerged as a fierce competitor to the US memory chip DRAM market, which led to trade tensions with the U.S. over perceived unfair practices. At the instigation of Micron, the US-Japan semiconductor agreement was signed to counteract the Japanese DRAM makers. Among the stipulations was price regulation, forcing Japanese companies to increase prices to parity with US chips, for Japan to agree to limit production volumes (voluntary restraint) and to encourage the sale of US chips in Japan[17]. This episode marked an opening point for South Korean and Taiwanese players to enter the DRAM market (refer to chapters 6 and 7).

Japan's semiconductor manufacturing industry peaked in 1988 and began a slow decline from then onwards. The key factors were the increased competition from emergent South Korean and Taiwanese players, slow adaptation to the rise of the fabless design house and foundry model, and the consequences of the Plaza Accord which forced a revaluation of the yen that crippled its export model. This had an effect of export diversion, with Malaysia and Thailand as some of the beneficiaries of Japanese relocation of manufacturing and export capabilities[18]. In an attempt to reverse the declines in semiconductor fortunes the Japanese government launched various initiatives in the 1990s and 2000s such as the Hinomaru Foundry, the ASKA project and the MIRAI project[19], which did little to regain Japan's dominance in the market.

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16. U.S. Congress, Office of Technology Assessment, Competing Economies: America, Europe, and the Pacific Rim, Ch6 Japanese Industrial Policy: The Postwar Record and the Case of Supercomputers
17. Johnson B, 1991, The U.S.-Japan Semiconductor Agreement: Keeping Up the ManagedTrade Agenda
18. Yusuf S et. al, 2009, Tiger Economies Under Threat - A Comparative Analysis of Malaysia's Industrial Prospects and Policy Options
19. Tomoshige H, 2022, CSIS, 2022, Japan's Semiconductor Industrial Policy from 1970s until today

In 2021, Japan unveiled an aggressive support strategy to revitalise its semiconductor industry by focusing on bringing back semiconductor manufacturing, particularly of advanced chips. It established JASM (Japan Advanced Semiconductor Manufacturing), a chip manufacturing joint-venture between TSMC, Sony and Denso. It has strengthened its partnership with the US in improving the security of advanced semiconductor technologies through various collaborations such as the LSTC and Rapidus. The Leading-edge Semiconductor Technology Center (LSTC) was launched in 2022 by the Ministry of Economy, Trade and Industry. It is a research institute that was established to develop advanced semiconductor technologies, supported by IBM. In the same year, Japan also saw the launch of Rapidus, an undertaking between 8 Japanese companies, supported by IBM and IMEC with the expressed goal of manufacturing the 2nm process by 2027.

Between 2021 and 2023, Japan is reported to have spent 0.71% of its GDP on various semiconductor initiatives, a higher proportion compared to that of the other OECD countries[20]. The initiatives were renewed at the end of 2023 with an additional budget allocation of USD13bn. Despite the decline of Japan's position in the semiconductor market from 50% in the 1980s to around 10% today, it still plays an important position in the global IC supply chain. It currently accounts for more than 80% of the global market for coater/developers, more than 50% of the global silicon wafer market, 50% for photoresists and approximately 40% and 30% of semiconductor test and fabrication equipment respectively[21]. This is yet another testament to the specialisation and concentration of certain segments of the supply chain, thanks in no small part to the various government-led initiatives and support towards building up local semiconductor firms over the years.

Table 5: Elements of Japan's semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
Japan	●			●	●	●	

Source: REFSA research

From this discussion we can see that the window of opportunity for Japan first came about in the 1950s with US foreign policy that enabled technology transfers to Japan. At that time there were already spearheading agents present, such as Japanese keiretsu, however the development of semiconductors was propelled through this window. Semiconductor nationalism came about only after the establishment of spearheading agents, one could say in 1949 with the creation of MITI. Today Japan sees another window of opportunity with close collaborative ties with the US to revitalise its domestic chip manufacturing industry and a revival of semiconductor nationalism with various initiatives and large amounts of fiscal support in place.

20. Tochibayashi N, Kutty N, World Economic Forum, 2023, How's Japan's semiconductor industry is leaping into the future
21. Brookings Institute, 2024, The Renaissance of the Japanese Semiconductor Industry

5.0 Semiconductor Nationalism in China

China's path of rapid development of its own domestic semiconductor players, culminating in today's chip war, is not unlike the tensions between USA and Japan in the 1980s. China's domestic tech sector has shown an incredible ability to narrow technological gaps, eating up global market share, much like the Japanese DRAM makers in the 1970s. But while Japan acceded to the USA's demands, China has not. Japan's rise was a policy goal of the US in the 1960s. Similarly China's rise was also partly due to the US government policy stance towards global trade and China in the 1990s and 2000s. The prevailing view in the US at that time was that the engagement and opening up of China's economy through trade liberalisation and WTO ascension will bring economic growth dividends and with it domestic political reform in China[22].

Table 6: Timeline of Chinese government key interventions in the semiconductor industry

Year	Policy / government actions	Detail
1957	Outline for Science and Technology Development	Establishment of semiconductor technology defined as an urgent priority
1960s	Establishment of electronics manufacturing	Dozens of state-owned semiconductor-related manufacturing factories were established
1965	Beginning of IC research	IC research programme began at the Chinese Academy of Sciences
1980s	Computer and Large Scale IC lead group	A working group to modernise the domestic semiconductor industry
1991-1995	Eighth four year plan	Project 908 to develop a leading integrated device manufacturer (IDM)
1996-2000	Ninth four year plan	Project 909 partnership with a foreign company to develop domestic chips
2000	Policies for promoting the development of software and IC industries	Income tax exemptions and various other support for domestic IC manufacturers and fabless companies.
2000	Establishment of SMIC	A successful hybrid model of semiconductor manufacturing company
2001	Ascension to the WTO	Liberalisation of trade and capital barriers between China and the world

22. Christensen T J, 2006, Fostering Stability or Creating a Monster? The Rise of China and U.S. Policy toward East Asia

Year	Policy / government actions	Detail
2006	National Medium and Long Term Science and Technology Development Plan outline for 2006-2020	IDAR which stands for "Introduction, digestion, assimilation and re-innovation" to drive the semiconductor strategy
2011	Renewed policies on promoting the development of software and IC industries	Introduction of tax incentives for IC companies using process rules
2014	Guidelines to promote National IC industry	Establishment of the National IC industry investment fund and a "local champion" plan with outbound FDI strategies
2015	Made in China 2025	Self sufficiency targets that included the semiconductor industry
2019	Second round of the National IC industry investment fund	Further funding of USD32bn for China's chip industry
2020	Policies for promoting High-Quality Development of the IC and Software Industries	A renewal of tax exemption policies of 2000 and 2011 together with additional manufacturing incentives and support
2023	Third round of National IC industry investment fund	Further funding of USD40bn with a focus on semiconductor manufacturing equipment for self sufficiency

Source: REFSA reseach

The raison d'etre of the semiconductor industry in China was not unlike that of the US and the Soviet Union in the beginning, being grounded on security and defence concerns. Semiconductors were identified as a priority industry in as early as 1957 in the China State Council's "Outline for Science and Technology Development 1956-57" twelve year development plan. The plan discussed strategies to close the technological gap in electronics with the Soviet Union among other ambitions. "Establishment of semiconductor technology" was task number 40 under the category of "New Technologies", out of the 55 tasks outlined[23]. It was identified as one of the crucial industries in which "urgent measures" were to be adopted, culminating in various electronics factories coming online soon after. Huajing Group Wuxi factory was one of them and would be a prevailing feature in China's industrial landscape, becoming a source for semiconductor talent in China as well as contributing to later industrial policies. It was said that by the time the Chinese Academy of Social Sciences commenced research into IC design in 1965, the chip industry in China was "at least as sophisticated as Japan"[24].

23. Wang, Z, 2016, Pg 195, The Chinese developmental state during the Cold War: the making of the 1956 twelve-year science and technology plan
24. VerWey J, 2019, United States International Trade Commission Journal of International Commerce and Economics, Chinese Semiconductor Industrial Policy: Past and Present

The development of the industry was halted during the cultural revolution between 1965-1975, and was resumed under Deng Xiaoping's economic reforms. However, the interruptions from the cultural revolution meant that the industry was set back 10-15 years in technology advancement. In the 1980s, out of the dozens of semiconductor manufacturing firms in operation, only Huajing Group was meeting production targets. The other plants performed poorly with yield rates between 20-40%, forcing the government to change tactics to focus only on a handful of firms with the aim of improving quality and productivity[25].

Moving away from relying purely on indigenous R&D, the 1990s to 2000s was characterised by heavy government investment into state-owned enterprise (SOE) semiconductor companies to pursue joint-ventures with foreign companies. The aim was to pursue tech transfers to develop national champions[26]. Project 908 was a project to develop a leading IDM, in joint-venture with Lucent technologies; however an eight year set-up process caused the project to produce chips that were out of date when it finally came online. Project 909 was a project to develop domestic chip-making capability together with a foreign chipmaker, in this case NEC. Hua Hong Semiconductor is China's second largest chipmaker today but not without suffering a host of problems during its growing years, including RMB200mn in losses during the DRAM downturn in 2002.

In the year 2000, a successful hybrid IC firm was established that combined ethnic chinese management and domestic labour force, with foreign-ownership and funding. Semiconductor Manufacturing International Corporation (SMIC) was founded as a wholly foreign-owned Shanghai-based chip manufacturer. SMIC benefited from various forms of indirect support such as tax holidays and tax breaks, tariff exemptions and access to financing. Using a fast follower strategy it has managed to narrow the technology gap with its competitors to emerge as China's largest contract chip manufacturer today. This has caused it to be a key target in today's chip war, being denied access to EUV lithography equipment which is required for the fabrication of the most advanced chips.

The year 2001 marked a turning point for China and the world as China gained entry into the WTO and was granted Most Favoured Nation Status. Prior to WTO ascension, technology transfers to China were greatly restricted by the 1996 Wassenaar Arrangement, which restricts countries from providing leading-edge technologies to Communist countries. 2001 paved the way for the opening up of global export markets to China, increased access to China's vast market to foreign investors, as well as relaxed technology transfer activity to China. "Between 2003 and 2020, the world's top destination country for semiconductor FDI was China, having attracted a total of $96.7bn-worth of projects, double that of the US over the same period" reports FDI Intelligence[27]. This had the effect of premature deindustrialisation in Southeast Asia as well as the hollowing out of manufacturing activities from established hubs such as Hong Kong and Taiwan. As a result of the relocation of manufacturing from Taiwan to new industrial zones such as Shenzhen, one researcher heralded this period as "one of the greatest IP transfers in human history of semiconductor technology from Taiwan to the mainland"[28].

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25. VerWey J, 2019, United States International Trade Commission Journal of International Commerce and Economics, Chinese Semiconductor Industrial Policy: Past and Present
26. Marukawa T, 2023, A Social Science Quarterly on China, Taiwan, and East Asian Affairs Vol. 59, From Entrepreneur to Investor: China's Semiconductor Industrial Policies
27. FDI Intelligence, 2023, The World's Top Semiconductor Investors
28. Saxenian A L, 2006, The New Argonauts

2006 marked China's shift in strategy towards technological catch-up by employing foreign technology acquisitions to spur the development of local capabilities. This IDAR strategy (introduce, digest, absorb and re-innovate) was outlined in the Technology Development Plan 2006-2020 by the State Council. It has been called an "advanced-imitation"[29] strategy and has been used successfully by China to narrow the gap in its defence capabilities. This concept takes into account the absorptive capacity of an economy towards new technologies, which is an important factor for the success of technology transfers. Post-IDAR, China introduced corporate income tax exemptions for semiconductor manufacturers in 2011.

2014 marked a change in focus from technological acquisition for defence purposes to semiconductor self-sufficiency. China began an ambitious effort backed by a funding largesse to actively acquire foreign technologies with the goal of self-sufficiency for its domestic market. This began with the establishment of the National IC strategy backed by a generous investment fund in 2014, followed by the Made in China 2025 policy announcement in 2015. With a planned budget of USD150bn, the National IC investment fund was to be funded by the Ministry of Finance, SOEs and city governments with the aim of developing all areas of the semiconductor supply chain domestically. The difference with prior years was the added strategy of outright acquisition of foreign companies (outward FDI) in addition to inward FDI in the form of JVs and technology transfer agreements.

Meanwhile, Made in China 2025 has a target aimed at increasing the ratio of domestic content in semiconductors to 49% by 2020 and 75% by 2030, together with other stated technology goals. Its Technical Area Roadmap spells out specific targets aimed at reducing China's technological gap with industry incumbents, with emphasis on areas such as advanced packaging, materials, equipment and DRAM chips. However as the targets are no longer mentioned in subsequent policy documents, it is unclear whether they are still being pursued.

The effects of the 2014 and 2015 policies were immediate as can be seen through the merger and acquisition activities of private companies such as the acquisition of Imagination Technologies in 2017, Nexperia and Beneq in 2018, Newport Wafer Fab in 2021[30] and Tsinghua Unigroup's minority stake in Lattice Semiconductor[31]. There have been many that have been thwarted due to national security concerns as well. Concurrently, the government continued to pour in heavy subsidies to promote indigenous design capabilities, such as Huawei's HiSilicon unit, with the aim to design homegrown chips for homegrown computers, automotive cars and equipment.

Throughout the years, China has combined various policy tools such as vast government subsidies, technology transfer as a condition for market access[32] and some argue a favourable exchange rate policy in order to further develop its domestic industries. The rise of Huawei is a testament to China's success in employing semiconductor nationalism to propel its domestic company to the global stage. Huawei has transformed itself into a tech leader, rapidly gaining global market share in various areas ranging from 5G technologies to port automation. The company that began as a simple reseller as early as 1990 clearly benefited from the Chinese

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29. Cheung T M, 2014, The Role of Foreign Technology Transfers in China's Defense Research, Development, and Acquisition Process
30. Datenna.com
31. Reuters, 2016, "Lattice shares soar after China's Tsinghua reports buying stake"
32. Miller C, 2022, Chip War: The First for the World's Most Critical Technology

government's assistance, in this instance vast subsidies[33] in various forms, from subsidised land, grants and credit facilities to tax breaks.

Today, China's big focus remains on semiconductor manufacturing production, together with an emphasis on equipment making as well as IC design as these are the current choke points in the trade spat with the US. Some say that the US policies are only accelerating the development of China's indigenous technologies and point to the US-Japan agreement as an example of how protectionist US policies did little to help its domestic chip-makers after all. However, the objective of today's trade war is not so much to protect US chip-makers, but about supply chain resiliency, as well as to thwart China's rise in the sector for advanced semiconductors and by extension its military dominance.

As can be seen through the concise history we just explored on China's industrial policies, China's position today as the fifth largest semiconductor producer in the world, with 16% share of the fabless market in 2020[34], is the product of years of direct government assistance mainly through two models of intervention, which are the entrepreneurial state approach prior to 2000s where SOEs were the main economic agents, and the investor state approach post 2000s, where the state role receded to investor and champion[35]. It is however also a costly affair, with China's experience peppered with failures as its state-run projects typically struggled to take off. China's experience demonstrates the large commitments required to develop this industry and its different approaches provide valuable lessons for countries wishing to embark on their own semiconductor nationalism strategies.

Table 7: Elements of China's semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
China		●	●		●	●	●

Source: REFSA research

China's semiconductor nationalism developed out of national security reasons and prior to the development of its semiconductor firms (ex ante). The window of opportunity was provided by entry into the WTO in 2001, which occurred after the development of its industry (ex post), allowing established firms to develop further such as Hua Hong, and the establishment of new firms. China's ecosystem is characterised by close interactions between its private sector, academia and its skilled workers, with vast amounts of government subsidies and support being poured into all three sectors.

33. Wall Street Journal, 2019 "State support helped fuel Huawei's global rise"
34. Semiconductor Industry Association, 2022, China's Share of Global Chip Sales Now Surpasses Taiwan's, Closing in on Europe's and Japan's
35. Marukawa T, 2023, A Social Science Quarterly on China, Taiwan, and East Asian Affairs Vol. 59, From Entrepreneur to Investor: China's Semiconductor Industrial Policies

6.0 Semiconductor Nationalism in Taiwan

Taiwan's economy was partly built by the large amounts of assistance from the US in the 1950s and 1960s. Between 1951-1963, Taiwan was said to have received USD1.4bn in economic assistance from the US in order to get the economy on its feet[36]. However it was technology diffusion through the education provided to the Chinese diaspora at American universities, that subsequently allowed them to work in Silicon Valley, that proved pivotal to the growth of Taiwan's semiconductor industry, which will become evident below.

Taiwan had set up export processing zones in 1966 as part of an export-oriented economic policy. The incentives provided, coupled with a cheap and efficient labour force made it an ideal place for low cost manufacturing. This attracted several semiconductor multinational companies to set up chip assembly plants on its shores. However in the 1970s, faced with increased competition from other low cost sites such as Malaysia, the government decided to move up the value chain with the establishment of the Industrial Technology Research Institution (ITRI)[37], a non-profit government funded research institute. Interestingly, ITRI was modelled after the Korean Institute for Science and Technology (KIST)[38] that was founded in 1966. ITRI through Electronics Research and Service Organization (ERSO) is most well-known for the creation of semiconductor giants such as United Microelectronics (UMC) and TSMC.

One of the first initiatives of ITRI was the RCA project, which involved the Taiwanese government purchasing technology for the design and production of chips from an American company called Radio Corporation of America (RCA). A technical advisory council was convened that consisted of Taiwanese American scientists and engineers to plan and execute the technology transfer. Interestingly, the goal of the project was not so much to get ahead in leading edge R&D, but rather how to use the chips to boost its consumer electronics industry. Hence, the decision of the technical advisory council to choose C-MOS technology, which was not the most cutting edge technology available at the time[39].

The establishment of TSMC marked another milestone for Taiwan and the semiconductor industry's first foray into the pure play foundry business. It was initiated first as a VLSI project by ITRI around 1985. At that time, there were many fabless design houses established in Taiwan who had to rely on spare capacities at the foundries of IDMs and contract them to manufacture their chips. They had approached the Taiwanese government for help. Seeing a market opportunity, Morris Chang[40] who was President of ITRI at that time, came up with the idea of creating an IC OEM[41], instead of investing individually in each IC design house to build many in-house fabrication facilities. Embarking on the latter would be extremely capital intensive and would not achieve large economies of scale.

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36. Jacoby N H, 1966, A.I.D. Discussion paper no. 11, An evaluation of US Economic Aid to Free China, 1951-1965
37. San G, 1990, OECD Development Centre Working Papers, The Status and an Evaluation of the Electronics Industry in Taiwan
38. Taiwan Today, 1994, "Technological Trailblazing"
39. ITRI Today, 2023, The birth of Taiwan's Semiconductor Industry
40. Many mistakenly believe that Morris Chang is Taiwanese but he was actually born and grew up in China. He then went to the US to further his studies and established an esteemed career in the semiconductor giants in the US prior to being sought out by Taiwan to head ITRI. Chang is an American citizen.
41. OEM stands for original equipment manufacturer and means companies that manufacture the products of other companies as a service, they do not own the brand or the technology of the product

Having one fab OEM that specialised purely on manufacturing wafers that all companies can contract with instead of many individual fabs only servicing each design house made sense. However, it was a new concept at that time and it was not easy at the start to get investors. Finally ITRI managed to crowd in investors by securing Philips as the anchor investor. For its manufacturing technology, it leveraged both technology transfer from Philips as well as advancements from its own VLSI research project[42]. Chang helmed TSMC and subsequently another spin-off, Vanguard International Semiconductor Corporation (Vanguard).

As a techno-nationalist state, semiconductors were always a national priority as well as a matter of national security, especially with regards to China. Due to cross-straits relations, Taiwan had prohibited investments into China and implemented the "No Haste, Be Patient" strategy that regulated Taiwan's outward direct investments into China[43]. However China's growth prospects, large market size and low manufacturing costs proved too mouthwatering for Taiwanese businessmen who started relocating lower value goods factories across the straits through third party vehicles since the 1990s.

But Taiwan regulated its semiconductor industry tightly, and strictly upheld a ban on opening semiconductor fabs in China[44]. With China's continued growth and impending ascension to the WTO, the government of Taiwan faced a dilemma. Denying fabs such as TSMC and UMC from opening up in China would make them less competitive to all the other fabs located in China that enjoyed lower costs of land and labour. Secondly, China tied access to its markets to FDI: no FDI, no market access. Denying Taiwanese chipmakers from investing in China also meant cutting off its access to a large and growing market, potentially damaging the companies' future prospects. Taiwan was also due to join the WTO in January 2002, a month after China, facing similar pressures on it to liberalise its trade and capital.

Taiwan's economy was experiencing a soft patch in the early 2000s, with slowing economic growth and rising unemployment. The administration feared that allowing its chipmakers to relocate to China would hollow out its industry and contribute to more unemployment. The situation was further complicated by vocal lobbying from Taiwan's semiconductor engineers union who opposed lifting the ban. Further, Taiwan had the advantage of being technologically ahead of China's chipmakers and did not want to lose this advantage to China. China's firms wanted to catch up to its neighbour, the risk of technology leakages was consequential and also a matter of national security.

After months of deliberations, Taiwan replaced the "no haste" policy with "Active management, effective opening" which facilitated further liberalisation of trade and capital flows coupled with tight regulatory oversight to maintain Taiwanese interests[45]. It allowed Taiwanese chipmakers to invest in China while ensuring that it continued to maintain its leading edge. One such example was permitting the building of 8" fabs in China, but only if these companies have 12" fabs in Taiwan. To ensure that R&D and the highest value added activities remained in Taiwan, the government pledged to increase its R&D spending by 10% annually and set an R&D target

42. ITRI Today, 2023, The birth of Taiwan's Semiconductor Industry
43. Taipei Times, Aug 2020, The value of Lee's 'no haste' policy
44. FES Asian survey, Jul/Aug 2003, Taiwan's dilemma across the strait, lifting the ban on semiconductor investment in China
45. Mainland Affairs Council, Mar 2006, Supporting Mechanisms for "Active Management, Effective Opening" in Cross-Strait Economic and Trade Relations

of 3% of Taiwan's GDP[46]. The strategy du jour was "Made by Taiwan but Made in China"[47]. This strategy proved to work and Taiwanese businesses flourished as a result, maintaining their headquarters and leading edge R&D in Taiwan, while taking advantage of the low costs and large markets in China.

Taiwan has ensured the development of its semiconductor industry through various measures such as R&D development that is closely tied to industry needs, rather than focusing on basic research. From the outset, the Taiwanese government would contract ITRI for projects that had immediate industry applications and funds ITRI with a budget of several hundred million dollars a year. ITRI is also partially self-sustaining, in 2023, 33% of ITRI's revenue sources came from private sector collaborations and 25% from government services. Funding from the government makes up the rest. ITRI became not only a force for R&D development in the industry, but also an incubator for tech companies as well as a training ground for technopreneurs and engineers.[48]

Table 8: Timeline of Taiwan government key interventions in its semiconductor industry

Year	Policy / government actions	Detail
1973	Establishment of ITRI	A non-profit research institution and incubator dedicated to advancing semiconductor R&D and high technology companies
1976	RCA project[49]	Technology transfer agreement with RCA for their C-MOS and N-MOS wafers.
1979	Establishment of the Hsinchu Industrial Park	A science-based industrial park that attracted multinationals and the overseas Taiwanese diaspora to return to set up tech companies
1980	Establishment of UMC	United Microelectronics is the spin-off of the technology transfer project with RCA
1984	VLSI project	ITRI's project to keep up with the latest developments in chip design and manufacturing
1987	Establishment of TSMC	TSMC was a spin-off of the VLSI project with some investment and technology transfer from Philips
1994	Establishment of Vanguard[50]	The first government-owned spin-off from ITRI that established Taiwan in the DRAM market

46. Yang C, Hung S W, 2003, Asian Survey, Taiwan's dilemma across the strait, lifting the ban on semiconductor investment in China
47. Tung C Y, 2004, UNISCI discussion papers, Economic Relations between Taiwan and China
48. ITRI sources, website and 2023 annual report
49. Huang L M, 2024, A Short History of Semiconductor Technology in Taiwan during the 1970s and the 1980s
50. Windham P, 2003, Securing the Future: Regional and National Programs to Support the Semiconductor Industry, Panel 4: The Taiwanese Approach

Year	Policy / government actions	Detail
1996	No haste be patient policy	Policies that limit Taiwan's outward direct investment to China
2001	Active management and effective opening policy	Replaced the previous policy, liberalising cross-strait links but under strict conditions and government oversight
2002	Taiwan's ascension to the WTO	Pressure to liberalise trade and capital flows, paved the way to improve trade and economic relations with China
2010	Establishment of a 3D IC R&D lab at ITRI[51]	This is Asia's first advanced packaging research lab for 3D packaging for 12" wafers, featuring through silicon via technology.
2021	ITRI joint project with ARM	Setting up of an innovative IC design platform
2023	Taiwan chips act	Features tax credits mainly for R&D with some provisions for capital expenditures.
2024	Chip-based Industrial Innovation Program	USD9.3bn allocated between 2024-2033 for innovation on existing technologies

Source: REFSA reseach

Today ITRI also conducts collaborative research projects with leading industry giants of the world, for example advanced packaging with Applied Materials and Rambus[52] and other projects involving Intel and Arm. Today, it is focused on integrating generative AI technologies into chips, as Phase 1 of the Chip-based Industrial Innovation Programme that begins in 2024[53]. The establishment of UMC, TSMC and Vanguard by ITRI and its continued advances in semiconductor R&D cements Taiwan's position as the world's leading manufacturer of semiconductors, with a global market share of 60%. Taiwan continues to invest heavily in its semiconductor industry while ITRI continues to win R&D awards. ITRI has been credited for Taiwan's successful move from low-value manufacturing into a high-technology semiconductor powerhouse. Meanwhile TSMC fabricates more than 50% of the world's chips and 90% of its most advanced chips[54]. Being an indispensable player in the supply chain today has been said to have created a "silicon shield" for the territory, and is credited to be a big deterrent to conflict in the Taiwan straits.

51. ITRI Today, 2023, The birth of Taiwan's Semiconductor Industry
52. National Academies of Sciences, Engineering, and Medicine, 2013, 21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program
53. Executive Yuan website, 2023, Taiwan Chip-based Industrial Innovation Program
54. Jones et al, 2023, US exposure to the Taiwanese semiconductor Industry

Table 9: Elements of Taiwan's semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
Taiwan			●			●	●

Source: REFSA research

From this investigation we do not see any significant window of opportunity that catalysed the growth of Taiwan's semiconductor industry. Rather, Taiwan's success was due more to semiconductor nationalism, a pool of Silicon-valley ethnic Chinese engineers that it tapped as well as from the massive efforts of ITRI and ERSO. Here it was semiconductor nationalism, marked by the founding of ITRI in 1973 that catalysed the development of Taiwan's spearheading agents (ex ante). Taiwan's research institute did more than R&D, it also provided a platform for returning talent and capital to create technopreneurs and start-ups. Locating ITRI in proximity with the National Tsinghua University, the Jiaotong University and technology companies, the Hsinchu Science Park has played a pivotal role and forms part of Taiwan's successful semiconductor strategy.

7.0 Semiconductor Nationalism in South Korea

Similar to the other Asian tigers such as Hong Kong and Taiwan, South Korea was one of the first outposts of semiconductor assembly activities in the 1960s. With the arrival of a few US electronics companies that needed talent, the US helped to fund the establishment of the Korea Institute of Science and Technology (KIST) to train up the labour force to supply its chip operations. MNCs used South Korea as a low cost manufacturing base with little in the way of technology transfer to develop the local industry. Much as Taiwan, Korea started facing competition from other lower wage sites, and the government decided to move up the value chain by prioritising wafer production as a response, identifying semiconductors as a strategic industry in its 1969 five year plan.

The 1969 five year plan for the development of electronic products was largely developed by Dr Kim Wan Hee, a Professor of Electrical Engineering at Columbia University. Dr Kim was recognised as a world-renowned scholar in the field of electronics in the 1960s and 70s and is largely credited with the birth of the electronics industry in South Korea. At the invitation of the South Korean government, Dr Kim devised the strategy and policies that underpinned government support for the electronics industry, in consultation with government, industry and experts from the US. His work consisted of studying the strategies of Taiwan and Japan, an analysis of the Korean economy and players, a technology roadmap, policy recommendations and an implementation strategy[55].

Prior to the 1980s, semiconductors was just another sector of the country's export policy[56], with several Korean firms entering the industry to produce electronic products for export, under government protectionist measures[57]. Early entrants into the semiconductor market in this period were Goldstar as well as small start-ups such as Integrated Circuit International and Han Kook Semiconductor, which was later purchased and integrated into the Samsung group as Samsung Semiconductor. Even though the policy was supported by tax incentives, there were no significant milestones during this period.

The enactment of the Science & Technology Promotion Act 1967 began the development of an R&D industry in Korea, with the founding of more government research institutes such as the Korean Institute for Electronic Technology (KIET), Korean Advanced Institute of Sciences (KIAS) and Daeduk Science Town. These institutes trained cohorts of scientists and engineers in many sectors in the 1960s to 70s[58], preparing the country's workforce for the demands of semiconductor technology in the years to come[59]. However unlike Taiwan's ITRI that played a pivotal role in creating leading edge technologies and spinning off companies, it is widely acknowledged that R&D activities played only a supporting role in the development of Korea's

55. KDI School of Public Policy and Management, The development of Korea's semiconductor industry during its formative years
56. Kim S R, 1996, The Korean system of innovation and the semiconductor industry: a governance perspective
57. KDI School of Public Policy and Management, The development of Korea's semiconductor industry during its formative years
58. 2009, OECD REVIEWS OF INNOVATION POLICY: KOREA
59. Chung S, 2009, Annual World Bank Conference on Development Economics, Pg 5, Innovation, Competitiveness, and Growth: Korean Experiences

semiconductor industry[60], which success is largely attributed to the efforts of Samsung and its contemporaries.

The 1982 Korean National R&D programme was buttressed by government incentives to develop the technology sectors, marking the turning point for the semiconductor industry. Lured by myriad financial and tax incentives for technology based startups and R&D, Samsung announced its intention to enter into semiconductor manufacturing with a pledge of USD100mn, followed by Hyundai and subsequently SK Group. After a careful study of the technologies available, Samsung decided to focus on the DRAM market for specific strategic reasons. This coincided with a shift in government policy away from consumer electronics to ICT, as well as a shift away from prioritising technology acquisition towards developing indigenous R&D. This was in part due to South Korea's focus on science and technology for economic development, viewed by its political leaders as a means to strengthen its political capital[61].

Table 10: Timeline of South Korea government key interventions in its semiconductor industry

Year	Policy / government actions	Detail
1966	Korea Institute of Science and Technology	To develop the labour force for the technology industry
1976	Identification of semiconductors as a strategic industry	The Chip industry was more a component of the export policy
1981	Basic Plan for Promotion of the Electronics Industry	Prioritises the development of the semiconductor industry with many policies crafted in support
1982	R&D incentives	Promotion of technology R&D in the private sector, technology-based start-ups and manpower development
1986	Public-private collaborative research project	Subsidies would be provided to conduct joint-research in the trench capacitor
1998	Big Deals	Aftermath of the Asian Financial Crisis: forced merger of ailing semiconductor arms of chaebols, resulting in the creation of Hynix from the sale of LG Semicon to Hyundai
1999-2002	Government support and bailout of Hynix	Korean government spent billions of USD to keep Hynix afloat
2021	K-Belt Semiconductor Strategy	Estimated USD66bn in tax incentives with USD1.3bn for R&D investments

60. Kim S R, 1996, Pg 28, The Korean system of innovation and the semiconductor industry: a governance perspective
61. Bak H J, 2020, The Politics of Technoscience in Korea: From State Policy to Social Movement

Year	Policy / government actions	Detail
2023	K-Chips Act	Tax incentives in the forms of deductions and credits for capital investments and general R&D
2024	Semiconductor Ecosystem Support package	Estimated USD19.1bn was announced for the improvement of the semiconductor ecosystem and provision of funding.

Source: REFSA reseach

The chaebols used three methods to acquire technologies, the first was to establish R&D outposts in Silicon Valley. Here they could access the best minds in semiconductor technology for development work and keep up to date with the latest trends. Second was through licensing technologies with US and Japanese firms, to the extent of forking out an estimated 16% of its annual turnover in royalty payments in 1992 - 85% of these reportedly to the US[62]. The third strategy involved providing contract manufacturing services to US and Japanese semiconductor companies. In the 1980s there was also purportedly a "strategic decision of U.S. semiconductor producers and computer companies to create an alternative, low-cost source for DRAMs in order to tamper oligopolistic pricing and supply behaviour of the Japanese majors"[63]. Samsung managed to purchase technologies from Micron Technologies, back when it was just a small start-up, as well as opened its own R&D outposts in Silicon Valley.

Samsung must have taken Japan and the US by surprise when they produced their first 64k DRAM chip in 1984, taking half the time it took for the incumbents from set-up to production, and barely a year after they announced their foray into the business[64]. By the time the chips came to market however they were a few generations behind the leading edge and the timing also coincided with a market downturn for the industry. However a window of opportunity opened up for Korean chipmakers to gain market share in 1985 with the signing of the Plaza Accord and in 1986 with the US-Japan Semiconductor Agreement. While Japan was forced to revalue the yen and control the price and quantity of its chips, South Korean producers benefitted.

Korean producers continued to gain market share until the Asian financial crisis of 1997. Hyundai and LG semiconductor divisions, who were not market leaders, and heavily dependent on debt, coupled with the overcapacity in the DRAM market, suffered heavy losses. The Korean government intervened to consolidate and reform its chaebols through "Big Deals"[65], part of the terms for Korea's acceptance of an IMF rescue package. One of these deals was to force the sale of LG semiconductor to Hyundai, which would also serve to trim the overcapacity in the DRAM market. When the sale finally went through a new entity called Hynix was created, however it was beset with legacy issues coupled with extremely unfavourable market conditions. It

62. Copenhagen Business School, 1998, pg21, Catching-Up, Crisis and Industrial Upgrading. Evolutionary Aspects of Technological Learning in Korea's Electronics Industry
63. Copenhagen Business School, 1998, pg20, Catching-Up, Crisis and Industrial Upgrading. Evolutionary Aspects of Technological Learning in Korea's Electronics Industry
64. U.S. Congress, Office of Technology Assessment, 1991 Competing Economies: America, Europe, and the Pacific Rim, Ch7 - The New Competitors: Industrial Strategies of Korea and Taiwan
65. US Department of State, 1998 Country Report on Economic Policy and Trade Practices: Korea

continued to post billions of dollars in losses, requiring government bailouts and funding until 2004 when it finally turned a profit. Hynix was sold to SK Group in 2012, becoming SK Hynix.

South Korea has been active in supporting its semiconductor industry again from 2021, when it unveiled its K-belt Semiconductor Strategy (estimated USD66bn), K-Chips Act in 2023 and Semiconductor Ecosystem support package (estimated USD19.1bn) in 2024. Areas of focus include the improvement of the semiconductor ecosystem from workforce development to R&D and infrastructure improvements. It also includes provision of funding in the form of low-interest loans to companies through the Korea Development Bank.

The initial success of the Korean semiconductor industry was much less through semiconductor nationalism than the pure commercial instincts and efforts of its chaebols, which leveraged initial government support in 1982 to penetrate the highly competitive DRAM market. As opposed to the Taiwan model, which used semiconductor nationalism to create chip giants, South Korea built up its big businesses in the heavy industrial and chemical sectors first through swathes of industrial policies and government support. The South Korean government's strategy was to invest heavily in improving its workforce through education and research activities, favourable policies and fiscal support for its conglomerates, as well as providing its chaebols access to copious amounts of capital in the form of low interest foreign currency loans[66]. The chaebols that grew from there subsequently led the foray into becoming heavyweights in the semiconductor industry.

This did not mean that the South Korean government was not actively supporting its semiconductor industry. The 1981 Basic Plan for Promotion of the Electronics Industry consisted of many measures to encourage the development of the semiconductor industry. An Electronics Support Fund was established, funded by public and private enterprises. One of the initiatives it funded was to establish R&D subsidiaries abroad. In 1984, Korea also enacted import tariffs on 37% of electronics import categories to protect its domestic players. In order to grow its domestic electronics players, the government mandated procurement of Korean made computers by government departments, followed by a complete ban on imports of microcomputers until 1988, coupled with domestic content guidelines for all its exports. These measures were in line with the 1984 Computer Industry Promotion Master Plan that prioritised the development of the computing industry, which also augmented South Korea's R&D budget for technology acquisitions.

Besides computers, the government also relied heavily on procurement policy in the telecommunications sector to push its players towards more advanced semiconductor capability. In the mid-1980s, the government embarked on a multi-billion project to upgrade and expand its telecommunications network. This project was to be taken up by joint-ventures of Korean industry leaders together with their global counterparts "offering lucrative and risk-free telecommunications business in return for the transfer of specified telecommunications and semiconductor technology"[67].

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66. Chung S, 2009, Annual World Bank Conference on Development Economics, Pg 5, Innovation, Competitiveness, and Growth: Korean Experiences
67. U.S. Congress, Office of Technology Assessment, 1991 Competing Economies: America, Europe, and the Pacific Rim, Chapter 7 - The New Competitors: Industrial Strategies of Korea and Taiwan

Samsung's balance sheets and those of the other chaebols allowed them to not only make the significant investments required for technology acquisitions, the poaching of key talent, setting up of capital intensive wafer fabrication plants, but also to weather the volatile DRAM market cycles. However, Korean government intervention during the Asian financial crisis and subsequent massive financial support for Hynix was pivotal in cementing South Korea's position as a major player in semiconductor manufacturing today. The decision to continue propping up Hynix, even turning down a sale to Micron[68], was partly a matter of national interest[69]. So while the government's involvement in the development of semiconductors was less prominent compared to the efforts of its chaebols, its willingness to endure the high costs of supporting Hynix and maintain it under Korean hands certainly speaks of semiconductor nationalism. Today, South Korea is the world's second largest producer of semiconductors[70], accounting for more than 70% of the global DRAM market. It also currently captures 17% of the global foundry market share.

Table 11: Elements of South Korea's semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
South Korea		●		●	●	●	

Source: REFSA research

A window of opportunity certainly helped South Korea's chaebols to make inroads into the DRAM market, partly through technology transfers and also through the weakening of Japanese chipmakers. This window of opportunity occurred only after the establishment of Korea's spearheading agents, in the later part of the 1980s (ex post). Similarly, when South Korea's government began to identify semiconductors as a priority sector, the chaebols were already present as large conglomerates in the South Korean economy. While South Korea certainly supported the sector with industrial and protectionist policies, semiconductor nationalism only really occurred in the aftermath of the Asian financial crisis (ex post), long after the establishment of its chip giants. This is evidenced by the large commitments and efforts by the government to prop up Hynix and keep it within Korean hands.

68. BBC, 2002, Hynix Ditches Micron Rescue Deal
69. Taipei Times, 2002, Hynix Workers Reject Micron Accord
70. Invest Korea Semiconductor

8.0 The Semiconductor industry in Malaysia

Malaysia currently holds the position of the 6th largest exporter of semiconductors in the world with 7% of global market and 13% of the OSAT share[71]. Malaysia's growth to prominence in the global semiconductor market was also not something that happened by chance. In 1972 the then Chief Minister of Penang, Dr Lim Chong Eu, launched Penang's first free trade zone with the establishment of the "8 samurais". It was the arrival of these eight electronics companies[72] from the US, Japan and Germany that set the stage for Penang and Malaysia's continued growth in the semiconductor industry. Dr Lim had decided to focus on the electrical and electronics industry as an engine of growth for Penang and as a solution to its rising unemployment.

Malaysia was one of the emerging low-cost locations for semiconductor manufacturing that challenged South Korea and Taiwan in the 1970s. Yet industrial growth in Malaysia stalled with the opening up of China as the world's manufacturing base in the 1990s. Like Taiwan, it also responded by intending to move up the value chain and its then Prime Minister Dr Mahathir Mohamed identified semiconductor wafer manufacturing as an industry of strategic interest, incorporating Wafer Technology (Malaysia) Sdn. Bhd., Malaysia's first domestically owned wafer fab, in 1995. However, problems and setbacks including the 1997 financial crisis delayed progress. The company finally began production in 2001 as SilTerra, right in the middle of the dotcom bust and the US 9/11 tragedy - the timing couldn't have been worse.

The rocky start set the tone for the rest of the company's history till its eventual sale in 2021. It continued to be plagued with issues due to mismanagement with a "revolving door of CEOs"[73] and was barely profitable with accumulated losses of RM8bn by 2021. Meanwhile the Malaysian sovereign wealth fund Khazanah that owned the company had sunk RM2bn into the company, or approximately 2% of Khazanah's 2021 net asset value[74] prior to its sale to a consortium of Chinese and Malaysian investors. Malaysia had tried to move up the value chain into semiconductor manufacturing through the development of its own wafer fab but failed. As can be seen in previous examples, the cyclical nature and R&D intensiveness of the chips market means that any serious player needs to have the firepower to weather the storms and be prepared for large, continuous and costly investments into R&D.

In 1996 and 1997, the then Prime Minister of Malaysia launched the Multimedia Super Corridor, which was modeled after Silicon Valley. It was aimed at agglomerating domestic and foreign tech companies with academia and capital to provide a breeding ground for Malaysian tech start-ups. The creation of Cyberjaya was to be the new city that symbolised the nexus of this "corridor". As can be seen, there was a holistic vision for Malaysia at that time to build its domestic chip manufacturing capabilities as well as create domestic tech start-ups in order to propel Malaysia forward in the knowledge and digital economy. These projects were all launched just prior to the 1997 Asian Financial Crisis, which put a dent on many of these plans.

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71. The Edge, Sep 2024, Securing Malaysia's position in the global semiconductor supply chain
72. The 8 samurai are National Semiconductor, Advanced Micro Devices (AMD), Intel, Litronix (now Osram Opto Semiconductors), Hewlett-Packard (now Keysight Technologies), Bosch, Hitachi (now Renesas) and Clarion.
73. The Edge, Jan 2019, Cover Story: Reinventing SilTerra
74. New Straits Times, Jan 2021, Dramatic twist to the SilTerra Malaysia Sdn Bhd sale saga?

Meanwhile the government continued to court more FDI into this sector while the private sector developed a handful of domestic OSAT players, equipment manufacturers as well as chip design companies. Rather than resulting from government directed policies, these companies developed on the back of entrepreneurs emerging from passive transfers of knowledge and a skilled workforce that was trained by the MNCs. Malaysia's position in the semiconductor value chain today has been due to the efforts of private sector agents coupled with FDI and industrial policies (although semiconductors were not given any preferential treatment). Malaysia's domestic players have also started establishing a regional and global footprint by acquiring foreign companies as well as opening plants offshore.

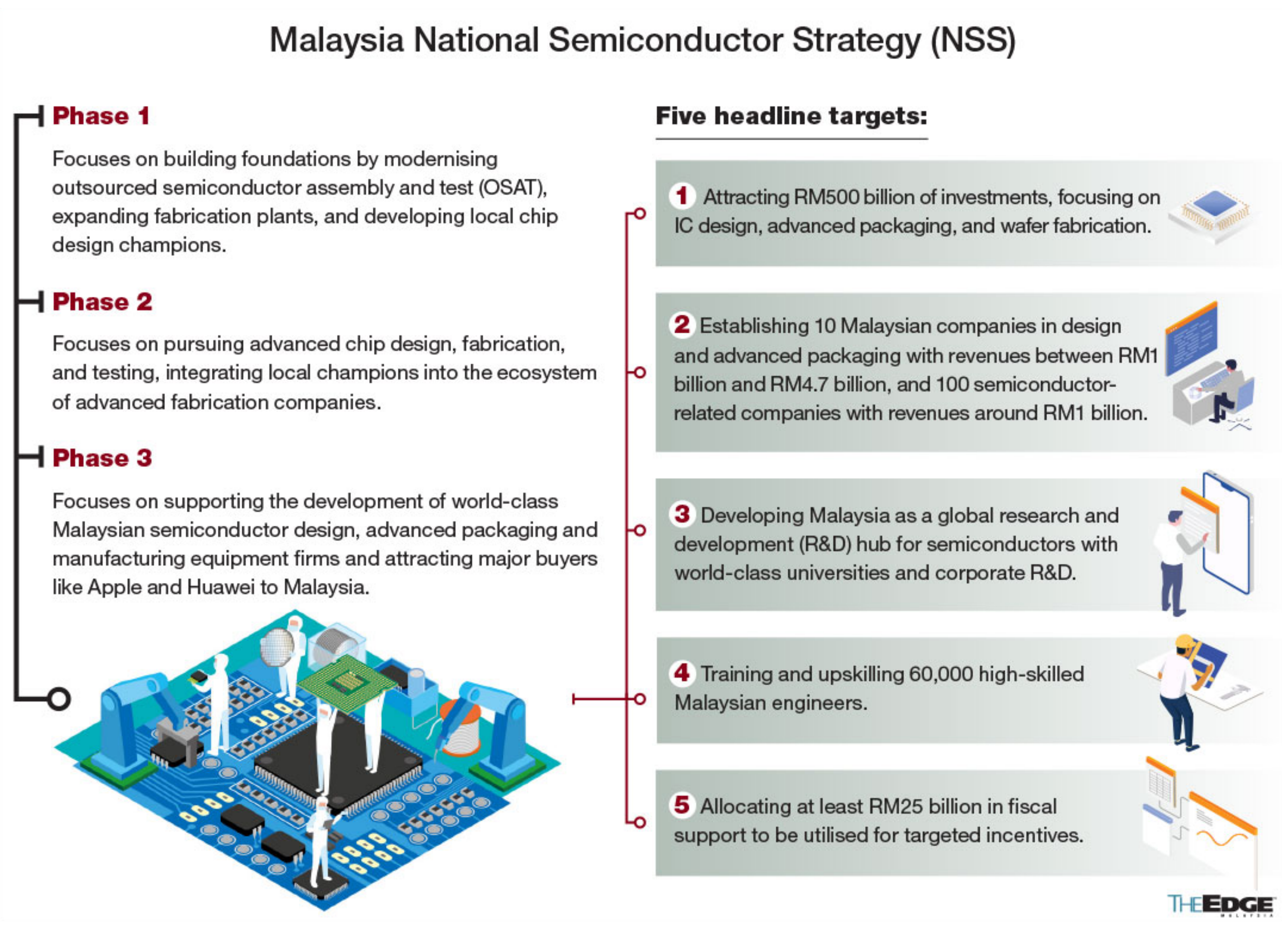
Table 12: Timeline of Malaysia government key interventions in its semiconductor industry

Year	Policy / government actions	Detail
1972	Establishment of the Bayan Lepas Free Industrial Zone	Identification of semiconductors as a key engine of growth in Penang
1995	Establishment of Wafer Technology, now SilTerra	Malaysia decides to move up the value chain into wafer fabrication
1996	Multimedia Super Corridor (MSC)	An area identified in the capital city to catalyse Malaysia's leap into the information age through various incentives for various companies in the multimedia and technology space. Modeled after Silicon Valley.
1997	Cyberjaya	Slated to be the capital and hub of the Multimedia Super Corridor.
2016-2021	Malaysia approves sale of SilTerra	Government allows divestment of SilTerra with foreign ownership conditions, the sale proceeded in 2021
2023	New Industrial Masterplan 2030 (NIMP 2030)	Semiconductors are identified as one of the key strategic sectors
2024	National Semiconductor Strategy (NSS)	Malaysia announces a semiconductor strategy outlining its intention to move up the technology value chain and develop its domestic players

Source: REFSA reseach

Although Malaysia is a non-inconsequential player in the global value chain today, there is still a sizable gap in its technological capabilities and R&D compared to the established players in the *comparator territories*. While it is ahead of the aspiring players such as Vietnam and India in terms of ecosystem development and experience, there are still hurdles present that Malaysia needs to cross in order to establish itself more firmly in the supply chain. Realising the opportunity that has opened up due to today's trade war, the Malaysian government has recently identified semiconductors as a preferred sector in the New Industrial Master plan 2030 (NIMP 2030). The goal of moving up the semiconductor value chain was communicated in its 2024 National Semiconductor Strategy (NSS), with the objectives of pursuing advanced chip design and advanced packaging. Malaysia clearly articulated a vision of building its own global semiconductor players as well as becoming a semiconductor R&D hub (see Graphic 2). Its intent to allocate at least RM25bn in fiscal support to be utilised for targeted incentives shows a commitment towards the NSS.

Figure 3: Malaysia's National Semiconductor Strategy



Source: The Edge

Malaysia's workforce has 50 years experience in OSAT as well as 30 years experience in chip design. Outside of the *comparator territories*, it also houses a handful of wafer fabs. Its biggest domestic players are OSAT players, followed by semiconductor equipment manufacturers, both of which are firmly entrenched in global supply chains. While it was provided with a window of opportunity in the 1980s with export diversion from Japan, it did not successfully capitalise on Japanese FDI to upgrade its domestic capabilities. Now, the window of opportunity has arrived again (ex post) and there are spearheading agents present as Malaysia develops its semiconductor strategy (ex post).

Table 13: Elements of Malaysia's semiconductor industry development

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
Malaysia		●		●	●	●	

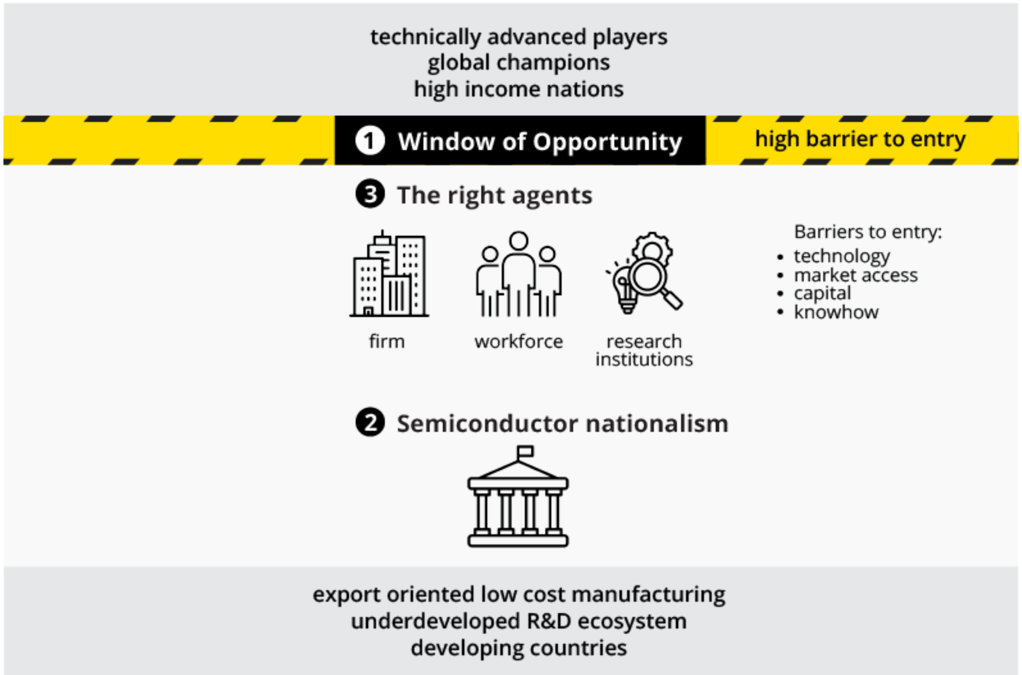
Source: REFSA research

In acknowledgement of today's geopolitical undercurrents, Malaysia's current Prime Minister offered Malaysia as the "most neutral and non-aligned location for semiconductor production" while unveiling the NSS, positioning Malaysia as a key consideration in global efforts to secure a resilient supply chain. Below we develop a framework for semiconductor success based on the experience of the *comparator territories* and analyse its implications for Malaysia.

9.0 Semiconductor Nationalism Framework for Success

In exploring the historical development of the semiconductor industries in the *comparator territories* above, we find that in addition to semiconductor nationalism, countries usually require at least one out of two more factors in order to successfully enter and maintain market share in the semiconductor value chain. These are the window of opportunity and the right spearheading agents. Figure 3 illustrates the landscape for semiconductor manufacturing and how the entrenched and technologically advanced players are separated by high barriers to entry from the emerging competitors. Common characteristics define the countries on both sides of this divide, as can be seen in the *comparator territories* which are all technologically advanced players, with global champions and typically high income nations (except China). Meanwhile the aspiring players such as Malaysia, Vietnam and India lie on the other side of the divide and share characteristics of being developing countries with lower cost manufacturing bases coupled with a relatively underdeveloped R&D ecosystem.

Figure 4: Three Factor Framework of Success in the Semiconductor Industry



Source: REFSA analysis

As mentioned, not all the criteria need to be present, as in the case of Taiwan, whose success was due less to a window of opportunity than successfully spotting a good business opportunity at the right time with the establishment of TSMC, as well as clever policy design during its entry into the WTO. The same is true of the US, which developed and sustained its dominance mainly through two criteria: semiconductor nationalism and the right agents. It can be argued that South Korea was successful from 1986 due to the window of opportunity and the right agents. It had a very general nationalistic industrial policy of supporting its chaebols, as Japan did with its keiretsu. Semiconductor nationalism only came to the forefront during the big deals of 1998 and subsequent support for Hynix. Table 8 shows a summary of the driving forces behind the success of semiconductor development in each of the *comparator territories*.

Table 14: Characteristics of Semiconductor Industry Development and Success

	Window of opportunity	Semiconductor nationalism	The right agents
US		●	●
Japan	●	●	●
China	●	●	
Taiwan		●	●
South Korea	●	●	●
Malaysia	●		

Source: REFSA analysis

Malaysia has been included in Table 8 as a basis for the discussion that follows. Global semiconductor nationalism has opened up a window of opportunity for Malaysia. However in order to benefit from this boon, Malaysia also requires at least one of the two other conditions in our framework, that of semiconductor nationalism and the right economic agents. Here we explore key questions for Malaysia to consider in its effort to seize this window of opportunity and offer suggestions from the prior case studies examined on how Malaysia could embark on its semiconductor strategy.

9.1 Window of opportunity

The semiconductor industry is characterised by many barriers to entry set up by incumbent firms. The barriers come in the form of technologies, market access, capital and knowhow. As can be seen in chapters three to seven, at times geopolitics or some exogenous factor opens up a window of opportunity for new entrants to enter the market. This window of opportunity serves to lower one or more of the barriers, creating a vacuum for new players to emerge. In the case of Japan, the window of opportunity came in the form of US foreign policy supporting its economy by way of technology transfers, capital, knowhow and market access. This window of opportunity effectively lowered most of the barriers for Japanese firms. In the case of China, the window of opportunity was the opening up of its markets upon its entry to the WTO which lowered barriers to capital, technology and trade. For South Korea, it was the US-Japan chip war that distorted markets and allowed their emerging semiconductor players to gain a foothold.

Semiconductor nationalism practised by other nations will at times bring about the window of opportunity, and catalyse semiconductor nationalism within another country as is the case with Malaysia today (see section 9.2). Meanwhile for Japan, accommodative US policies allowed Japanese companies to licence technologies, paving the way for Sony to build its first transistor radio and advance in the tech industry. The rise of the semiconductor industry in Japan emerged from the window of opportunity for technology transfer in the 1950s onwards, and only grew to become a strategic industry for Japan in the 1970s. In this case we say that the window of opportunity is ex ante, meaning that it precipitated the development of the semiconductor industry in Japan.

At other times, there is already an existence of sizable domestic semiconductor players in territory, before the window of opportunity comes along to allow that country to either gain market share and/or technologies. We refer to the window of opportunity here as ex post, meaning occurring after a domestic semiconductor industry has been established. China has been trying to develop its semiconductor industry since the post world war two era, but results were lacklustre. It was not until its ascension to the WTO when things really started to change. This is an example of an ex post window of opportunity, where although China had developed domestic players, it was not very successful until the window of opportunity provided by WTO entry occurred, which had the effect of lowering barriers to entry mainly in the form of market access and technology transfers. Meanwhile we did not recognise any significant window of opportunities in the development of the domestic semiconductor industries in the US and Taiwan.

Table 15: Window of opportunity can happen ex ante or ex post of domestic semiconductor industry development

	Window of opportunity	
	Ex ante	**Ex post**
US		
Japan	●	
China		●
Taiwan		
South Korea		●
Malaysia		●

Source: REFSA analysis

An opportunity for Malaysia. Today as semiconductor nationalism heats up between the US and its allies against China, a vacuum is being created in the supply chains of both nations. The US suffers from the high costs of having lost its tacit knowledge and ecosystem for semiconductor manufacturing to East and South East Asia for most of the 1990s and 2000s. Meanwhile China has lost its access to tools for high end chip design and fabrication equipment. Much as South

Korea and Taiwan benefitted from the US-Japan chip war in the 1980s, a window of opportunity has similarly opened up for Malaysia precisely due to semiconductor nationalism of the US. Malaysia is benefiting due to two strengths: the first being **Malaysia's conducive semiconductor ecosystem owing to its 50 year establishment as a low-cost manufacturing base for multinationals, and second as a historically neutral country that is neither aligned to the US nor China.** As there is already the presence of domestic players in the semiconductor industry, it is characterised as an ex post window of opportunity for Malaysia.

The opportunity consists of companies that are currently manufacturing in China for export to the US (Chinese and global companies such as Taiwanese, Japanese, European and American) looking for alternative production hubs in order to circumvent US tariffs and to build supply chain resilience. Outside of China, the only other lower-cost hub with many years of semiconductor manufacturing experience and ecosystem is Malaysia. Hence semiconductor players have been flocking to Malaysia as part of a "Non-China, Non-Taiwan" strategy. However the country faces stiff competition from incumbent as well as emerging players globally who are trying to localise supply chains (incumbents) or gain a piece of the pie (emergents) through generous incentives and government support.

9.2 Semiconductor nationalism

Semiconductor nationalism is the use of industrial policy and foreign policy to establish, develop and protect the domestic semiconductor industry for national and economic interests. In semiconductor nationalism, domestic semiconductor companies become a geopolitical and geoeconomic issue, defining national interests through the interplay of economics and national security. However in the experience of each *comparator territory*, semiconductor nationalism is usually driven predominantly by an economic or national security factor (see Table 16). For Malaysia it is driven by economic considerations rather than a matter of national security.

Table 16: Main objectives of semiconductor nationalism

	Semiconductor nationalism	
	Security	**Economic**
US	●	
Japan		●
China	●	
Taiwan	●	●
South Korea		●
Malaysia		●

Source: REFSA research

Below we have identified 6 key elements of semiconductor nationalism - recognition of importance, technology acquisition, protectionism, development, foreign policy and capital - and proceed to analyse how it may apply to Malaysia.

9.2.1 Recognition of importance

Semiconductor nationalism typically begins when a country recognizes the industry or technology as a key asset to be protected and/or developed, and is willing to go to great lengths to establish and grow its own players, even at high costs. It can also begin when its semiconductor industry or national security is under threat, leading to similar actions as just described. In semiconductor nationalism, domestic semiconductor companies become a matter of national pride, a question of national sovereignty and a main engine of economic growth. While Taiwan was already used as a low-cost semiconductor manufacturing base by multinationals, it was not until the government decided to commit funds and efforts towards the domestic industry's development that culminated in the formation of Taiwanese players. Meanwhile the South Korean government continued to prop up Hynix even at the cost of billions and stayed the course until market conditions improved, not wanting it to fall into foreign hands.

The industry is accorded strategic importance, influencing foreign policy decisions and accorded preferential treatment over other industries. In Chapters 3 to 7 we see territories employing strategies to develop, protect and promote their domestic chip industry. These come in the form of policies that act on trade, taxes, R&D, market access, funding, costs, financial structures and technology. As can be seen in the prior examples, interventions can range from being dictatorial as in the China entrepreneurial state model and Japan's tight oversight on managing IPs and FDIs on a company by company basis, to more private sector led such as in the US. In fact, all *comparator territories* feature heavy government intervention in one form or another in the form of restrictions and coercions, the US included due to the recent CHIPS act.

While China and the US recognised its importance in military use, its value to other economies such as South Korea and Japan was more commercial, as an engine of economic development and growth. For Taiwan, while semiconductors were developed for economic reasons, the industry has come to dominate the national security agenda. As is characteristic of economic development, the national importance of these industries grew in tandem with their success and increase in their global market shares.

Malaysia. The Malaysian government rightly sees this opportunity and would like to seize it not only to further develop its semiconductor industry, but also for the growth of this industry to meet its national strategic goals and socio-economic objectives. Besides wanting to move into a knowledge economy, Malaysia has also recognised the importance of improving its labour share of income. Hence the overarching aspiration of the NSS is for Malaysia to build its own domestic global champions, and in doing so to develop the local supply chain, uplift the whole industry and create spillover economic benefits. It is hoped that with building its own domestic giants and locating high value activities in Malaysia it can grow wages and incomes of Malaysians. In these aspects Malaysia has recognised the value of the semiconductor industry in becoming a key engine of growth and socio-economic development of the nation.

The NSS outlines RM25bn allocation for targeted fiscal incentives to develop the sector. However this was not followed through in the 2025 budget announcement. Little funds have been provided for the operationalisation of NSS and a fiscal incentive plan has yet to be announced. While Malaysia has recognised the importance of the sector, it may not fully grasp the efforts that are required in order to realise its ambition of bringing its domestic companies to the global stage. This requires a fundamental shift in mindset in the public and private domains, from a long entrenched laissez-faire approach to business, to a more nationalistic and protectionist approach. The prevailing stance towards industrial development is tilted to favour FDI rather than domestic investments, without a focus on building our own large Malaysian technology players. However as demonstrated in the experience of the *comparator territories*, this shift in approach is critical to the success of the development of domestic semiconductor players.

9.2.2 Technology acquisition

It can be seen from all the preceding examples that a key coveted factor was technology, without which none of the countries would have been able to establish themselves firmly in the semiconductor supply chain. **Naturally semiconductor nationalism was very much preoccupied with the protection, development and acquisition of technologies,** as can be seen in the case of the US, who recognised early on that semiconductor technology was an asset to be protected for national security reasons. Meanwhile Taiwan's preoccupation was with ensuring that leading edge technologies were not leaked in its outward FDI to China. Firms will already protect technology for competitive advantage and countries also enacted policies for national security reasons.

Technology acquisition was key for the new entrants. China spent years trying to catch up with various policies on technology acquisition and up till today has still not managed to close the gap on advanced chips. Japan got an early head start with Sony's technology licensing agreement from AT&T in the 1950s and provided ample support for its keiretsu to move ahead, while Taiwan's advantage was the pool of Taiwanese and ethnically Chinese engineers working in Silicon Valley that it tapped. South Korea had a policy that prioritised building domestic capabilities, to bring American style education to its own shores and massive funding into government research institutes. While its research did not contribute directly towards the advancement of semiconductor technology in Korea, its efforts built the R&D ecosystem that was crucial for technological advancement, producing the talent that fueled the R&D labs and factory floors of its chaebols in the early days.

Various technology acquisition policies were used by the *comparator territories*, some formal and some less so. The formal routes such as technology licensing agreements, outright purchases and joint ventures were available but only at the host firm's/country's discretion. In these instances the transfer of outdated or lower value manufacturing process technologies was usually the case. China had used access to its domestic market as a leverage point to coerce foreign companies to share technology and know-how, enforcing localisation policies to develop its own domestic firms. China and Japan also preferred limiting FDI to joint ventures to promote technology transfer from the foreign to the domestic partner. Japan also pursued tight control over its tech acquisition with technology import policies in the 1950s and 60s to coordinate, curate and manage its technological advancement[75].

75. Lynn L H, 1998, Int. .J Technology Management, pg556-567, Japan's technology-import policies in the 1950s and 1960s: did they increase industrial competitiveness?

There are also collaborative research projects, where participants pool resources not only to develop technologies together but also learn best practices from each other in the process. Another method employed by China from 2006 onwards was outward FDI, where Chinese companies pursued an active policy of acquiring foreign companies for their technologies. **Meanwhile informal channels come in the form of talent,** where key talent is poached over to the new firm to enable technology transfer. South Korea was purported to have hired talent from its Japanese competitors in order to build its own capabilities, as well as by establishing R&D centres in the US. Reverse engineering and contract manufacturing were other informal methods, used particularly by South Korea to try and close the gap[76].

At the beginning, the US was the clear technology leader with the rest being followers although today different territories lead in different segments of the value chain. Territories first began by tech acquisition but moved on to develop their own indigenous technologies as they moved on to higher value activities. **This move from technology absorption, to innovation and then to creation was a key policy goal of semiconductor nationalism.** In conclusion, from a technology perspective, semiconductor nationalism can be seen as a tool that is used by incumbent countries to enact barriers to protect technology while emerging players use it to acquire technology.

Malaysia needs more technology. Here we believe that Malaysia is at the technology acquisition stage and with pockets of indigenous technology development. The nascent advanced packaging technology provides an opportunity for technology co-development and catch-up[77] as it is a new field globally. Malaysia has leading equipment makers and OSAT players that may be able to make some headway into this sector with some technology transfer initiatives through triple-helix arrangements[78] and government support. Geopolitical tensions mean that China is currently facing some chokepoints in chip design software as well as in advanced chip manufacturing equipment. Malaysia must consider if it can and wants to fill this vacuum at the risk of repercussions from the US.

As technology acquisition is a costly affair, Malaysia should be strategic in its appropriation. Examples of factors that would weigh into consideration are technology maturity, technology life cycle, market size, related applications, commercial value, synergy with existing agents, synergy with existing economic activities and relevance to solving national challenges. ITRI and Korea's Electronics and Telecommunications Research Institute (ETRI) focused on applied research projects rather than more upstream basic research and this is a strategy Malaysia could consider. As Malaysia has developed knowhow in manufacturing process technologies and has an advantage in this area due to its experience in manufacturing, this is another area of research it could focus on.

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76. Princeton University, Jan 1991, pg319, Competing Economies: America, Europe, and the Pacific Rim, Chapter 7—The New Competitors: Industrial Strategies of Korea and Taiwan
77. Lee, Keun, Economics of Technological Leapfrogging (2019). UNIDO Department of Policy, Research and Statistics Working Paper 17/2019
78. Triple-helix in this context is a term to mean mean interaction between academia, industry and government

Another key consideration is also how the technology would be acquired. Here there are many tools such as licensing, purchasing, joint ventures, collaborative research, talent acquisition, outward FDI and follower strategies. In addition, would the technologies be acquired on a shared basis or on a firm level basis, and how would these be funded. The *comparator territories* all embarked on government funded joint research projects with varying success. This is a model that Malaysia should study to consider its relevance to its needs today.

9.2.3 Protectionist policies

Protectionist policies usually have two intertwined but distinct objectives, the first to protect IP, and the second to protect the commercial interests of the indigenous firm. Both of these feature regularly in semiconductor nationalism. They are intertwined because high value exclusive technologies are usually correlated with commercial value.

IP protection. Today's chip war arises from national security or IP rather than commercial reasons.The USA certainly enacted many policies to protect their IP by restricting technology transfer to China and the Soviet Union. Companies are also more hesitant to establish manufacturing and R&D facilities in jurisdictions where IP laws are weaker. Japan had a technology import restriction policy in the 1950s and 60s that allowed it to vet, curate and manage technology acquisitions of its companies. The country also delayed IP applications to allow its firms to imitate products without incurring IP costs and consequences. Meanwhile IP law was invariably used by companies as a tool to prevent other companies from copying a product or method.

Commercial protection. Countries in East Asia have been accused of maintaining unofficial **exchange rate policies** to favour domestic exports. **Trade policies** in the form of trade agreements, tariffs, quotas and trade barriers have also been enacted to protect domestic producers from foreign imports. Some protectionist measures come in the form of restricting domestic market access to imports, or delaying FDI approval for companies that would compete directly with domestic firms as in the case of Japan. The US Japan chip war in the 1980s was all about protecting the commercial interests of US chip firms.

There are also non-trade barriers that can be enacted to protect domestic industries in the form of regulatory requirements, as well as the imposition of limits and quotas for foreign ownership and workforce. These measures serve to protect not only commercial interests but also take into account other political considerations each country may have.

Malaysia faces threats. Here a key question for Malaysia is whether it should protect its semiconductor industry from uncompetitive behaviour of certain global companies who are benefitting from domestic support and subsidies. There are many approaches that the government can take depending on each individual case. In the case of cheap imports, Malaysia should tread carefully as the price of an import component may compete directly with a local industry and yet, may be the critical input of another. Here a cost benefit analysis should be undertaken to decide the best course of action. The options are to do nothing, to place tariffs, to restrict quantity or to enforce a localisation policy-type rule. All come with their pros and cons that must be carefully considered.

Another area is resource competition where MNCs directly compete with Malaysia's domestic industries for talent, inputs and products. Malaysia needs to identify its priority industries and craft policies based on the maturity stage of the sector itself. There is a balance between allowing firms to grow and develop capabilities while ensuring that they do not become overly reliant on government support, making them uncompetitive in the global markets.

Stringent IP laws have been shown to be counterproductive when a developing country is in the IP acquisition stage[79]. However Malaysia needs to balance its need to catch up quickly with its need for strategic FDI and tread mindfully. Malaysia can build and leverage its competitive positioning as a mature and established semiconductor manufacturing hub to encourage more technology transfers. Such technology transfers could be positioned as a supply chain resilience play, where Malaysia provides a secure and resilient semiconductor base that bridges the East and West. In such a scenario, having strong IP laws is crucial to the strategy.

9.2.4 Development policies

These policies typically come in the form of tax incentives, subsidies, funding and provision in three key areas, the first for R&D to develop technologies, the second to encourage capital investment for manufacturing facilities and third to develop local talent. Most *comparator territories* had/have supportive policies for all three areas especially in the beginning when domestic players were smaller and did not have enough resources for R&D, capital nor talent.

Malaysia's NSS has pledged RM25bn in fiscal support and a large part of this is envisioned to comprise of tax incentives, subsidies, funding and provision in areas such as R&D for commercialisation, collaborative R&D projects, shared R&D facilities, development of domestic suppliers, technology acquisition and for local talent development.

R&D is a key feature of development policy. Government support as a % of R&D tends to be higher in the beginning, and if successful, is overtaken by the private sector as companies reap the rewards of the initial R&D investment and start to take on a bigger share of R&D expense. This trajectory can be seen clearly in the US, Japan, South Korea and Taiwan. R&D as a % of GDP also tends to be higher when countries enter the phase of developing their indigenous R&D. South Korea purportedly spent USD1.2bn in R&D between 1983 to 1986[80], from less than 1% prior to the 1980s, as it switched its priority from technology acquisition to indigenous technology development.

The R&D ecosystem in Malaysia should be improved. Funding for semiconductor research in the government research institute MIMOS, Malaysia's national applied research and development centre, has not been consistent, stifling advancements in semiconductor technology. Further, Malaysia's R&D expenditure as a percentage of GDP stands at 1% as of 2020[81] lagging behind that of South Korea (4%), Taiwan (3.4%) and Singapore (2.2%)[82]. The government has recognised

79. Lee, Keun, Economics of Technological Leapfrogging (2019). UNIDO Department of Policy, Research and Statistics Working Paper 17/2019
80. U.S. Congress, Office of Technology Assessment, 1991 Competing Economies: America, Europe, and the Pacific Rim, Chapter 7 - The New Competitors: Industrial Strategies of Korea and Taiwan
81. Statista, Expenditure of research and development as share of gross domestic products in Malaysia from 2020 to 2022
82. Free Malaysia Today, Aug 2024, Govt mulls law to mandate minimum 2% of GDP for R&D

the importance of establishing a ripe ecosystem for R&D and its role in derisking R&D activities for its domestic firms. There are plans to increase its R&D spend with a Science, Technology and Innovation Act, coupled with a Malaysia Science Endowment Fund.

Localisation policy is another such policy that has been used to develop domestic industries. It refers to requiring MNCs that come into the host country to use local suppliers in their set up, manufacturing inputs and operations. Countries such as China have used this policy successfully to develop their own local supply chain players to serve the needs of the MNCs. In addition, government **procurement policy** has also been used to develop local industry, where the government becomes the main source of demand to support and develop industry. ITRI is a good example of development policy, where the government contracts it to do research work. It also acts as an incubator, with funding from the government to spin off successful research work into commercial enterprises and earning it a good return in the process. South Korea had also embarked on protectionist policies coupled with domestic procurement policies to build local capabilities as well as facilitate technology transfers.

In Malaysia, there is no formal localisation policy and its effects need to be studied. Enforcing a localisation policy will decrease Malaysia's competitiveness and attractiveness as an FDI destination. Policies for market penetration, where semiconductor diplomacy is used to open up key MNC accounts and access to their global markets for our local players, could be the preferred strategy. In such a scenario, Malaysian companies benefit from a larger global sales market rather than just being confined to Malaysian FDI. This would have the effect of making Malaysian products more competitive globally and increase its outward FDI. In today's geopolitical environment, Malaysia means neutral and this is a plus for many MNCs, the barrier is ensuring that Malaysian players are able to meet the procurement standards of the MNCs and get through the supplier qualification process. The government also needs to ensure the ecosystem is conducive for Malaysian suppliers to be able to meet customer demands reliably and consistently. Here a key consideration is the maturity and capability of the sector, with appropriate policies designed according to its stage of development.

Industrial policy is a key element of semiconductor nationalism and development. Today countries such as the US and their Western allies are giving out large grants and incentives for firms to set up wafer foundries within their shores. Wafer fabs are extremely complex, capital intensive investments, costing tens of billions of dollars. Countries that have long offshored their manufacturing capabilities to lower cost regions and moved up the value chain towards higher value activities such as R&D and design, are now re-embracing industrial policy with fervour. Companies have been coerced with capex incentives to lessen the pain[83] to onshore and friend-shore advanced semiconductor manufacturing. Although the incentives given to offset capital costs are generous, the ecosystem for advanced chips is weaker and performance is yet untested in the US. Much of wafer fab manufacturing is concentrated in Asia - China, Japan, Taiwan and South Korea - precisely due to the cost-performance factor[84].

83. Building and operating manufacturing facilities is estimated to cost 7% more in the US compared to Taiwan (TechInsights, Jones, 2020, Cost Analysis of the Proposed TSMC US Fab). In addition, the US has lost much of its tacit knowledge in the construction and operation of wafer manufacturing facilities making the process relatively more difficult.
84. CSIS, Feb 2024, A Strategy for The United States to Regain its Position in Semiconductor Manufacturing

Malaysia's advantage. Malaysia has the added advantage of 50 years of experience as a value semiconductor manufacturing hub, approximately 30 years of experience in IC design and the presence of a handful of wafer fabs. A mature ecosystem of suppliers, equipment makers, specialised construction capabilities, facilities, services and trading infrastructure has taken root. Industry insiders have remarked that the performance of manufacturing facilities in Malaysia is comparable or better than counterparts elsewhere, even at headquarters of the MNCs themselves. This has been a reason for the explosion in manufacturing investment activity from MNCs lately such as Infineon, Intel and ASE Group[85]. Malaysia has latent capabilities in key areas of the value chain, supported by a strong semiconductor equipment manufacturing cluster.

Meanwhile the US needs to ensure that it can secure its supply of chips in times of crisis, and Malaysia can position itself favourably to offer that. Industrial policy in the form of cash incentives to set up manufacturing plants in the high-cost base economies in the West is needed to lure fabs to set up. However Malaysia's value proposition that allows companies to plug and play could perhaps make it an attractive destination for semiconductor manufacturing activities even without such generous incentives. Companies report on set-up times and construction timelines in Malaysia that are faster compared to its projects elsewhere, coupled with an administration and supply chain that is mature and experienced in such investments. **Malaysia could position itself to offer a reliable, secure, safe and resilient supply chain, as this is in itself a cost effective strategy for firms.**

Another form of development policy tool is **export oriented incentives**. Export subsidies are deployed to allow companies to penetrate global markets and gain market share. It encourages firms to be competitive globally as a method of improving quality and getting companies to up their game. It is usually used to incentivise firms not only to improve their product and technologies but also their branding, communications and marketing strategies, as it is usually more difficult to compete globally than in the domestic market. **Malaysia can choose to adopt such export oriented incentives in a targeted manner** that would allow it to penetrate difficult markets. It is good to bear in mind that costs are no longer semiconductor firms' main concern today. Rather, close proximity to suppliers and customers for supply chain resilience, and geopolitical considerations where Malaysia's neutrality provides it with a competitive advantage, are the key factors driving boardroom decision-making at present.

9.2.5 Foreign policy

A key feature in semiconductor nationalism is its influence on foreign policy and vice versa. Semiconductor technology has become a strategic foreign policy tool, and is only allowed to be transferred to friends and allies and kept strictly out of the hands of state enemies. This also means trade restrictions on advanced chips, software design tools and manufacturing equipment feature increasingly in policy. The US government has pursued sanctions on companies that violate these trade restrictions. Now a firm's nationality and supply chain sources

85. Infineon is in the process of setting up one of the world's largest and advanced silicon carbide wafer fabs in the world in Malaysia, Aug 2024, Infineon. Meanwhile ASE Group is the world's largest outsource assembly, test and packaging provider, it is expanding its facilities in Malaysia with a USD300mn investment, 2022, ASE Group. Intel's advanced packaging facility Pelican is slated to come online in 2024.

are key points of contention. Cross border merger and acquisition activity deals are scrutinised and blocked less due to anti-competition reasons but more on national security concerns. The era of semiconductor diplomacy has emerged where the topic of semiconductors has more often become a key feature in and even a key reason underpinning diplomatic engagements.

Malaysia should leverage its neutral position, mature ecosystem and semiconductor manufacturing know-how to negotiate for the areas that it lacks, such as capital, technology and key talent.

9.2.6 Capital

Another key feature of semiconductors is the high costs of developing this industry. As can be seen from the experience of all the *comparator territories* above, costs range from the extremely high set up costs of a fab, to the continuous R&D that is required, to having a cash pile to weather the cyclical nature of the industry. BCG estimates that the total cost of owning a fab over ten years in the US to be in the region of USD30-40bn[86].

In addition, the R&D expense is an extremely capital intensive endeavour, with highly uncertain cash flows and returns. It follows that bank lending is traditionally adverse to providing funds for R&D activities. It needs to be funded with upfront cash, and the timeframes can often be uncertain. R&D often needs patient capital, sources of which are fewer compared to funding for other types of projects, and is usually heavily subsidised by the government at the outset. Only when firms are large enough with established market share and balance sheets can they take on a higher proportion of R&D. Firms typically rely on lots of government support to reach that stage, as can be seen in all the case studies explored above.

As can be seen from historical experience, the chip market is highly cyclical and prone to periods of overcapacity. The market is highly exposed to economic cycles and supply is inelastic due to long lead times for fab set-up, leading to very uneven market dynamics and volatile pricing. Companies that venture into this must not only contend with high costs of continuous R&D, they also run the risk of massive overcapacity or a slump in the market when facilities come online. A consequential amount of capital is required to be successful in this game, as can be seen in all prior examples.

It can be said that **capital is a weakness of Malaysia especially when compared with the *comparator territories***. Hence Malaysia's fiscal bullets should be deployed very strategically and as part of a holistic semiconductor nationalism strategy in order to be most effective. A main financial objective of the fiscal incentives should be to build up the balance sheets of key firms with the criteria that they should continue to invest larger proportions of their revenues in R&D. Companies who receive funding should also be required to support local players to improve domestic supply chain resiliency and indigenous capabilities. Another goal is to increase total R&D as a share of GDP, and to gradually increase the private sector's share of that spend. The ultimate aim would be to build companies with strong global market shares and consistent cash flows to enable them to entrench themselves in high value markets and R&D activities.

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86. Boston Consulting Group, Sep 2023, Navigating the Costly Economics of Chip Making

Another angle Malaysia could consider is whether it has existing companies that can take on a large share of the R&D expenditure required, as well as have the resources to expand market share and manufacturing activities as in the case of the chaebols of South Korea. India and Thailand have embarked on this path by establishing their own wafer fabs by partnering up a large domestic conglomerate with an MNC. Tata Group and TSMC in the case of India, and PTT Group and Hana Microelectronics in the case of Thailand. It is interesting to note that Tata Group is India's equivalent of a chaebol while PTT Group is Thailand's state-owned oil and gas company.

A pertinent question is whether the Malaysian government can commit in terms of support and political will to see through policies that are not only costly but may have a long gestation period before bearing fruit. Malaysia had embarked on establishing its own wafer fab in the form of Silterra in 1995, but did not anticipate the large, sustained capital commitments that were required to sustain the business. Other similar projects such as the protection of the automobile industry to grow its own local carmaker Proton, as well as the health of its national airline Malaysian airlines are examples where government direct intervention into a firm may not be the best strategy for Malaysia. In this regard it might follow in the footsteps of the US, by investing in creating a fertile environment and ecosystem for the development of its own private enterprises instead of directly picking winners.

9.3 The right spearheading economic agents

Another key ingredient for the success of a semiconductor industry are the right economic agents. These consist of **firms, the workforce and research institutions, which are the targets on which semiconductor nationalism policies act upon.** These agents may exist prior to semiconductor nationalism, or they may arise as a result of semiconductor nationalism. Table 17 illustrates for each country, whether the window of opportunity and semiconductor nationalism preceded (ex ante) or happened after (ex post) the development of spearheading agents, while the rest of the analysis goes on to explain the reasons for each.

In the case of Taiwan, agents such as ITRI, UMC and TSMC arose from government efforts at developing its semiconductor industry. Only talent was a pre-existing factor. Close relations between the US and Taiwan meant that many Taiwanese graduates of US universities became intimately involved in the rise of Silicon Valley. However it required the government to identify semiconductors as a strategic sector and the various efforts that came along that allowed Chinese ethnic engineers in the US to return to Taiwan to set up companies and join the workforce. The tacit and technical knowledge they brought with them effectively lowered barriers to entry for Taiwanese firms.

Table 17: Window of opportunity and semiconductor nationalism expressed as ex ante or ex post the development of spearheading agents

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Ex ante	Ex post	Firms	Workers	Research institutions
US			●		●	●	●
Japan	●			●	●	●	
China		●	●		●	●	●
Taiwan			●			●	●
South Korea		●		●	●	●	
Malaysia		●		●	●	●	

Source: REFSA research

Contrast this with South Korea, where its chaebols were already present with strong balance sheets and expertise in heavy industry and chemicals. The government had declared semiconductors as a strategic industry early on in the 1970s, yet this policy was not very successful until the 1980s when the chaebols themselves made the commercial decision to commit to becoming major DRAM manufacturers. This decision was helped in part by the generous government policies for the high-tech sector, as well as driven by the search for new growth drivers by the companies themselves.

While Taiwan's main agent of development was its research institution ITRI that held the technologies, funds and talent, in South Korea the main agent was the firm, which developed the tech and capital. Both governments invested in the ecosystem to produce talent through initiatives to bolster domestic academic institutions. Taiwan's industry developed from all three agents while Korea developed from just two, with the research institution playing a backseat role, although South Korea did spend considerable amounts on its research institutions[87]. This is similar to Japan, whose development was firm-led with research institutions playing a secondary role.

Meanwhile China faced the issue of creating the ideal agents in a centrally planned economy. Its efforts to develop semiconductor firms produced more failures than successes such as project 908, 909 and their predecessors. Internal troubles and restrictive foreign policies also stunted the development of its domestic workforce and technological capabilities. However its opening up in the 2000s enabled freer flow of talent, technology transfer and the development of the

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87. ETRI had 1200 staff and a budget of over USD40mn in 1985 - U.S. Congress, Office of Technology Assessment, 1991 Competing Economies: America, Europe, and the Pacific Rim, Chapter 7 - The New Competitors: Industrial Strategies of Korea and Taiwan

private sector firms in addition to the SOE. Later incarnations of semiconductor firms were more successful where the Chinese government played the role of ecosystem enabler and took a more market-led approach to the development of the private firms (SMIC, Hua Wei). So in the case of China, the right agents were created from the window of opportunity, but were preceded by semiconductor nationalism.

In Malaysia, there are already established players in the semiconductor industry with a global footprint. While they are not yet large enough to take on global competitors in a meaningful way, some of them for example ViTrox is rapidly gaining market share from its competitors, while others such as Greatech and Inari have established a global presence by either acquiring foreign companies or establishing foreign manufacturing sites. There exists a cluster of domestic, agile and competitive firms in the Malaysian semiconductor scene that semiconductor nationalism policy can act upon to bring to the next level.

Workforce is an area of concern not only in Malaysia but worldwide. A situation is brewing within the country where large companies set up and pinch talent from local players and Malaysian SMEs, due to labour market shortages. While this is good for Malaysian workers who benefit from higher salaries, it stifles the growth and development of domestic SMEs. This can be remedied in several ways, one of which is to provide supportive talent policies for local companies to be more competitive in the job market. Another is to benchmark salaries against international standards and adjust the labour supply with targeted immigration interventions, which can be done in addition to local company talent subsidies.

MIMOS is Malaysia's technology and applied research centre while Universiti Sains Malaysia (USM), a renowned educational institution in Malaysia, currently houses a nano optoelectronics lab and a compound semiconductor lab. The latter has been cited as being one of the reasons underpinning certain MNCs decision to base their compound semiconductor manufacturing activities in Malaysia. However the landscape for R&D in research institutes and academia would benefit from the injection of fresh capital, talent and crucially, a few mission-based government procurement programmes that crowd-in capital, involve the participation of domestic and foreign companies and facilitate technology transfers.

10.0 Conclusion

The established semiconductor players in the global value chain today - US, Japan, South Korea, Taiwan and to a certain extent China - provide valuable lessons in industrial policy and semiconductor nationalism for aspiring players. While the combination of strategies and tactics differ, a comparison of their experience in Chapters 3-7 uncovers some underlying similarities underpinning their success, which are a window of opportunity (applicable to all except the US and Taiwan), semiconductor nationalism and the right spearheading agents. Semiconductor nationalism is a loose term to characterise the level of government commitment in terms of funding and policies that are required to advance semiconductor domestic players, as well as the importance of the sector in a country's national agenda, to the extent that it influences geopolitics. Massive subsidies and R&D investments are required to increase a country's absorptive capacity for semiconductor technology and investments. Meanwhile the strategic importance of the industry sometimes exerts influences on foreign policy decisions.

Table 18: A summary comparison of success factors influencing semiconductor nationalism

	Window of opportunity		Semiconductor nationalism		Spearheading agents		
	Ex ante	Ex post	Security	Economic	Firms	Workers	Research institutions
US	■	■	●		●		●
Japan	●			●	●	●	
China		●	●		●	●	●
Taiwan	■	■	●	●		●	●
South Korea		●		●	●	●	

Source: REFSA analysis

Today's geopolitical tensions and semiconductor nationalism between the two global powers US and China opens up a window of opportunity for Malaysia. In order not to miss this chance, Malaysia needs to carefully craft its semiconductor nationalism strategy and implement the right policies to shape this wave of supply chain reorganisation to its maximum benefit. While the geopolitical rivalry is playing to its benefit, it needs to consider the extent of its ambition, where semiconductor nationalism requires large capital investments and a whole of government approach. In terms of economic agents, another crucial factor for success, Malaysia has the right firms but unable to retain talent to grow the industry. Labour market inefficiencies need to be addressed. Last but not least, the R&D ecosystem is underdeveloped and this is a crucial ingredient for success to move up and away from being a low-cost manufacturing hub into a high-tech, high-income economy.

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