India

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India's commercial semiconductor industry is currently on a growth catapult.[1] It is expected to grow from 119 billion USD in 2021 to 300 billion USD by 2026, with a compound annual growth rate of 19 per cent. This positioning on an upward trajectory has been possible because of numerous systemic policy decisions taken by the Indian government in the past decade (from 2012–2022). The semiconductor industry is not new to India. India's semiconductor design industry, over the years, has carved a worldwide niche and the Indian semiconductor ecosystem is now preparing to expand from design-only to design and large-scale assembly, testing, manufacturing and packaging capabilities.

India's semiconductor design competencies have long existed. These were operated directly by the Department of Electronics (now branched into the Ministry of Communications and Ministry of Electronics and Information Technology), government-owned companies and strategic agencies, the Defence Research Development Organisation and Indian Space Research Organisation. Until 2010, the Indian government and its strategic agencies had their designed semiconductor chips contract manufactured abroad.[2] India had no policy architecture that would allow semiconductor or higher-order, full-spectrum electronics manufacturing to become competitive and grow in the commercial realm. Indian semiconductor design engineers account for approximately 20 per cent of the global semiconductor design workforce.[3] They are deeply involved in numerous pre-silicon processes – specifications, architecture, design, physical implementation and manufacturing support. This tremendous workforce is also engaged in post-silicon (post-manufacturing) processes like testing and

[221] 'Semiconductor component market to grow at CAGR 19%', *Trade Promotion Council of India*, 17 August 2022, https://www.tpci.in/indiabusinesstrade/news_buzz/semiconductor-component-market-to-grow-at-cagr-19/#:~:text=The%20semiconductor%20component%20market%20of,Market%20Report%2C%202019%2D2026.
[222] Kamaljeet Singh and S.V. Sharma, 'Semi-Conductor Ambience for Building Self-Reliance in the Country', *ICTAT Journal on Microelectronics* 03:04, 2018, pp. 488–493, https://ictactjournals.in/paper/IJME_Vol_3_Iss_4_Paper_7_488_493.pdf.
[223] Ministry of Electronics and Information Technology – Press Information Bureau, 'Semiconductor Chip Designing and Manufacturing', Government of India, 6 April 2022, accessed 10 December 2022, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1814029.

qualification. India's massive talent pool made it a preferred destination for global original equipment manufacturers (OEM) to set up offshore semiconductor design facilities.[4]

Since the announcement of the Indian government's 'Make in India, Make for World' flagship policy in 2014 and the national India Semiconductor Mission (ISM) in 2021, India has taken steps in a short period to graduate into a pivotal global electronics and semiconductor manufacturing hub. This aspiration was strengthened by intense domestic and regional international demands forecasted for the region. India's consumer electronics and appliances manufacturing is estimated to contribute as much as one-fifth of national gross domestic product by 2025.[5]

Besides these national targets, India's economic growth, as forecasted by global credit rating agencies and multilateral financing institutions, its robust domestic governance instruments and the strong confidence expressed by global investors have collectively convinced global semiconductor companies to set up manufacturing units in India.[6] In the coming decade of the 2020s, a few large (giga) fabs and numerous outsourced semiconductor assembly and test (OSAT), as well as assembly, testing, marking and packaging (ATMP) units, will appear in India. These will serve India's massive domestic and, of course, global markets.

1. Government

The Indian government has laid an extensive and continuously maturing policy framework for establishing a large semiconductor and electronic hardware ecosystem in India as a high priority. The broadest of the policy frameworks are the pan-Indian government 'Make in India', 'Digital India', 'Start-up India' and 'Skill India' campaigns. In recent years, the Indian government has carried out numerous systemic reforms that were earlier inhibiting the gestation of high-technology manufacturing in India.

[224] Chitra Giridhar, 'India's niche: semiconductor design services', *EDN*, 24 October 2006, last accessed on 10 December 2022, https://www.edn.com/indias-niche-semiconductor-design-services/.
[5] Ishita Guha, 'Electronics manufacturing will contribute $1 trillion by 2025', *The Mint*, 18 December 2020, last accessed 15 December 2022, https://www.livemint.com/news/india/govt-sees-electronics-manufacturing-contributing-one-fifth-to-economy-by-2025-11608288599559.html.
[6] Chris Anstey, 'India's Economic Ascendance May Happen This Time', *Bloomberg*, 26 November 2022, last accessed 15 December 2022, https://www.bloomberg.com/news/newsletters/2022-11-26/india-s-economic-ascendance-might-just-happen-this-time-new-economy-saturday.

The 'Make in India' campaign works towards enhancing India's 'Ease of Doing Business' (EODB) rankings, which are maintained by the World Bank. India's consistent efforts have resulted in India's EODB ranking rising from 142nd globally in 2014 to 63rd globally in 2020.[7] India's rankings are further expected to move up the charts, owing to sector-specific production-linked incentive (PLI) schemes, which were started in March 2020 and are explained later in this chapter. The EODB-driven reforms stimulated by the 'Make in India' campaign have helped the Indian government repeal nearly 2,000 antiquated laws from the British colonial era that would inhibit the smooth setting up and accomplishment of mundane business activities.[8]

The second framework – of importance for the semiconductor and electronics design and manufacturing industries – has been the pan-government 'Digital India' campaign. Within the ambits of the 'Digital India' campaign, the Indian government established a not-for-profit company, the Digital India Corporation, in September 2017.[9] The Digital India Corporation is mandated to assist the Indian government in policy and implementation related to the 'Digital India' campaign, to promote public–private partnerships, to offer a skilled workforce from the digital sector to various governmental ministries and agencies, and to promote innovation. In December 2021, the India Semiconductor Mission was launched as an independent division within the Digital India Corporation, with an incentive outlay of approximately 9 billion USD to attract investments in the semiconductor sector. The ISM is working on the following four schemes:[10]

- Fiscal support for setting up semiconductor fabs in India: with up to 50 per cent of project cost for fabs making 28nm or lower nodes; up to 40 per cent of the project cost for fabs manufacturing 28–45 nm; and up to 30 per cent for those manufacturing 45–65 nm.
- Fiscal support of 30 per cent of the total capital expenditure to eligible applicants for establishing silicon photonics, compound semiconductor, sensor (including MEMS) fabs and semiconductor ATMP or OSAT facilities in India.

[7] Make in India, 'Ease of Doing Business', Government of India, accessed 15 December 2022, https://www.makeinindia.com/eodb.
[8] 'British-era laws scrapped, ease of doing business rank escalated: PM Modi lists achievements', *The Mint*, 11 October 2022, accessed 15 December 2022, https://www.livemint.com/news/india/britishera-laws-scrapped-ease-of-doing-business-rank-escalated-pm-modi-lists-achievements-11665424421886.html.
[9] Digital India Corporation, 'About DIC', Government of India, https://dic.gov.in/.
[10] Ministry of Electronics and Information Technology – Press Information Bureau, 'MoS Shri Rajeev Chandrasekhar to visit Gandhinagar tomorrow to flag off the first SemiconIndia Future Design Roadshow', Government of India, 16 October 2022, last accessed 15 December 2022, https://pib.gov.in/PressReleseDetailm.aspx?PRID=1868283#:~:text=The%20Government%20of%20India%2C%20in,in%20the%20strategic%20Semiconductor%20sector.

- Fiscal support of up to 50 per cent of project costs (condition to a ceiling of approximately 1.4 billion USD per fab) for establishing thin-film-transistor liquid-crystal display or active-matrix organic light-emitting diode display fabrication units in India.
- A Design-Linked Incentive Scheme that offers various financial incentives, design infrastructure support at various stages of design (up to 50 per cent to a ceiling of approximately 1.8 million USD per application) and deployment (6–4 per cent of net sales over five years) of integrated circuits, chipsets, system on chips, systems and IP cores.

The Indian government's production-linked incentive scheme known as the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS), which was announced on 1 April 2020, offers a financial incentive on 25 per cent of capital expenditure for various semiconductor-related goods.[11]

Another scheme executed by India's Ministry of Electronics and Information Technology is the Modified Electronics Manufacturing Clusters (EMC 2.0) Scheme.[12] This scheme involves governmental assistance with establishing new and greenfield electronic manufacturing clusters and assists electronics system design and manufacturing (ESDM) entities in establishing their bases in these clusters with shared facilities and amenities. The EMC 2.0 will also upgrade infrastructure in existing and brownfield industrial estates and industrial parks by developing common facilities and amenities for ESDM entities. Of the benefiting ESDM entities, EMC 2.0 intends to support one anchor entity that would purchase 20 per cent of the saleable or leasable real estate and make an investment higher than approximately 37 million USD for establishing a new electronics or semiconductor manufacturing entity. For smoother execution of the EMC 2.0, India's central and state governments have collaboratively formed a governing council, project review committees and project implementation agencies for every state, as well as a singular project management agency operating as an autonomous body of India's Ministry of Electronics and Information Technology (MEITY).

[11] Ministry of Electronics and Information Technology – The Gazette of India, 'Notification – Scheme for Promotion of manufacturing of Electronic Components and Semiconductors (SPECS)', Government of India, 1 April 2020, last accessed 19 December 2022, https://www.meity.gov.in/writereaddata/files/scheme_for_promotion_of_manufacturing_of_electronic_components_and_semiconductors.pdf.

[12] Ministry of Electronics and Information Technology – The Gazette of India, 'Notification – Modified Electronics Manufacturing Clusters (EMC 2.0) Scheme', Government of India, 1 April 2020, last accessed 19 December 2022, https://www.meity.gov.in/writereaddata/files/modified_electronics_manufacturing_clusters_scheme.pdf.

On the skilling front, numerous industry associations – partnering with the Electronic Sector Skills Council of India, a not-for-profit body – have been skilling and training the workforce required for the ESDM sector, at all levels of qualification, in association with the National Skill Development Corporation, a not-for-profit company operated by India's Ministry of Finance.[13] Another important initiative of the MEITY is the Chips to Startup (C2S) programme.[14] The C2S aims to train human resources for the semiconductor industry in India in designing application-specific integrated circuits, field-programmable gated arrays, systems, and creating an academia–industry interface with universities, national laboratories, start-ups, and small and medium-scale enterprises. The India Chip Centre at the Centre for Development of Advanced Computing, an autonomous scientific society under the MEITY, has been identified as a nodal entity to gather chip designs from academia and industry participating in the C2S. The India Chip Centre sends the gathered chips to the Semiconductor Laboratory (another MEITY laboratory) for fabrication under the multi-project wafer mode.

On the start-up front, and under the 'Start-up India' campaign, financing and incubation of semiconductor start-ups have already begun. The Karnataka Innovation Society of the Government of Karnataka, along with the India Electronics and Semiconductor Association, has established the Semiconductor Fabless Accelerator Lab, which currently involves eleven portfolio companies and more than 80 ecosystem companies.[15] In October 2022, the Atal Innovation Mission of Niti Aayog (the Indian government's foremost policy think tank) and T-Hub, a renowned start-up incubator supported by the Government of Telangana, based in Hyderabad, selected ten start-ups for their AIC–T-Hub Semiconductor Program.[16]

India's central government does not carry out all the semiconductor-related policies in India. Of course, the Karnataka and Telangana state governments are both rearing semiconductor start-ups. However, some other industrious state governments in India have also had their own ESDM and semiconductor policies.[17] These policies commonly have the respective state government's subsidies and incentives on land procurement, water availability, electricity duty and power tariffs, as well as exemption on

[13] Electronics Sector Skills Council of India, 'A Study to Assess Employment Potential and Skilling Requirement', Ministry of Skill Development and Entrepreneurship, Government of India, 2019, last accessed 15 December 2022, https://www.essc-india.org/wp-content/uploads/ESSCI_Market%20Research-PCB_SC.pdf.
[14] Ministry of Electronics and Information Technology, 'Chips to Startup', Government of India, accessed 15 December 2022, https://www.c2s.gov.in/.
[15] K-Tech Center of Excellence for Fabless, 'Semiconductor Fabless Accelerator Laboratory', https://www.sfalcoe.com/.
[16] NITI Aayog – Atal Innovation Mission, 'AIC T-Hub Foundation', https://old.t-hub.co/aic-semiconductor-program/.
[17] These include the Karnataka Semiconductor Policy 2010, the Maharashtra Electronics Policy 2016, the 2nd Telangana Information Communication Technology Policy 2021-26, the Tamil Nadu Electronics Hardware Manufacturing Policy 2020, the Andhra Pradesh Electronics Policy 2021-24, the Madhya Pradesh Analog Semiconductor Fab Policy, the Uttar Pradesh Electronics Manufacturing Policy 2020, the Rajasthan Electronics Manufacturing Policy 2021, and the Gujarat Semiconductor Policy 2022.

stamp duties. Among the non-fiscal support given, the state governments commonly offer uninterrupted power and water supplies, assistance with effluent and hazardous waste management, single-window clearance during the initial stages of business establishment and ease of doing business self-certifications.

To summarise, India's semiconductor policies and execution plans span various ministries, agencies, and departments of the state and central governments. They interlink within the national campaigns, yet it is the India Semiconductor Mission that assumes the flagship role for developing the semiconductor ecosystem in India. The Indian government comprehends the necessity to offer fiscal incentives, infrastructural support, and smooth project implementation and execution as non-fiscal support.

2. Overview of the local industry

India's semiconductor market size is growing steadily because of the various PLIs, including those for electronics, mobile phones, displays and semiconductors. Although the pre-silicon era did not see India become an influential player in the global semiconductor industry, concerted efforts taken by the Indian government since 2014 have swung the scenario constructively in India's favour.

The fiscal support offered under the India Semiconductor Mission, around 9 billion USD, is substantial. In US dollar terms, globally, the Indian semiconductor market stood at 15 billion USD in 2020. By 2026, this market is expected to reach 63 billion USD.[18] Owing to the incentives of the India Semiconductor Mission, in the last quarter of 2022 the Taiwanese semiconductor company Foxconn (Hon Hai in China and Taiwan) entered into a joint venture with Indian conglomerate Vedanta to set up a 20 billion USD semiconductor fabrication unit constructing 28nm semiconductor nodes in India.[19] In the coming years, India may have an even more significant share in semiconductor design, could have several sector-specific OSAT and ATMP units, as well as a sizeable domestic market that is well connected with markets in Asia, Oceania and Africa.

[18] Ministry of Electronics and Information Technology, 'Semicon India takes a step forward with Acceptance of Applications for Semiconductor and Display Fabs', *Government of India*, 19 February 2022, last accessed 19 December 2022, https://pib.gov.in/PressReleasePage.aspx?PRID=1799621.

[19] Vedanta Limited, 'Vedanta signs MoUs with Government of Gujarat to set up semiconductors and display fab units', https://www.vedantalimited.com/img/media_mentions/press_release/2022/Vedanta%20signs%20MoUs%20with%20Govt%20of%20Guj%20to%20set%20up%20semiconductors%20and%20display%20fab%20units.pdf.

The Indian electronics hardware manufacturing landscape had many impediments earlier. India was afflicted by a high cost of manufacturing, of up to 8–10 per cent, across various ESDM value chain stages *vis-à-vis* competing economies like China. The share of the domestic value chain in the ESDM segment has been merely between 10 and 30 per cent, primarily because of the absence of a semiconductor and display manufacturing ecosystem. This deficient domestic value chain was not gaining from the bill of material, which constitutes a sizeable portion of any electronic product. Another major impediment to attracting investments in domestic semiconductor and electronic hardware manufacturing was the nil basic customs duty on electronic components and semiconductors under the Information Technology Agreement-1 (ITA-1) of the World Trade Organisation (WTO). India has opted out of any further ITA expansion negotiations. It has chosen to promote manufacturing that was severely affected by ITA-1.

The semiconductor and electronics industries demand world-class public infrastructure, which has been in the works in India through a whole-of-government approach. India is currently working on the National Infrastructure Pipeline, which will witness investments of around 1.3 trillion USD. The investments will extend over five industrial corridors under the National Industrial Corridor programme, six freight corridors under the Dedicated Freight Corridor programme, 100 smart cities (including greenfield and brownfield) under the Smart City Mission, and economic corridors, logistics parks and numerous expressways under the Bharatmala project. The National Infrastructure Pipeline is a force multiplier for the proliferation of electronics and semiconductor manufacturing across India.[20]

One inherent advantage of manufacturing semiconductors in India is the enormous domestic and regional market volume, including mobile phones, industrial electronics, consumer electronics, strategic electronics, computer hardware and electronic components. Domestic production across these categories had already seen a measurable rise, even during the pre-PLI and pre-ISM years. The post-PLI and post-ISM years, when ESDM policies have matured and investments have poured in, are likely to show a steep rise in production.

[20] Department of Economic Affairs – Ministry of Finance, 'National Infrastructure Pipeline – Report of the Task Force', *Government of India*, accessed 21 December 2022, https://dea.gov.in/sites/default/files/Report%20of%20the%20Task%20Force%20National%20Infrastructure%20Pipeline%20%28NIP%29%20-%20volume-i_1.pdf.

Table 2: Overview of semiconductor businesses, industry bodies and R&D laboratories in India

Noteworthy semiconductor companies in India	**Country of origin**
Tata Elxsi	India
ASM Technologies	India
Polymatech	India
Dixon Technologies	India
SignalChip	India
Solex Energy	India
Vedanta	India
HCL Technologies – Sankalp Semiconductors	India
MIC Electronics	India
RIR Electronics	India
Tessolve	India
Moschip Technologies	India
SPEL Semiconductors	India
Saankhya Labs	India
Chiplogic Technologies	India
Continental Device India	India
Cirel Systems	India
Manjeera Digital Systems	India
Semtronics Micro Systems	India
Terminus Circuit	India
Bharat Electronics Limited	India
Wipro Engineering/NXT	India
Samsung Semiconductors	South Korea
TSMC	Taiwan
Micron Technology	US
Applied Materials	US
Broadcom Technologies	US
Lam Research	US

GlobalFoundries	US
eInfochips – an Arrow Company	US
NXP India	Netherlands
ASM Pacific Technology	Netherlands
Millux	Netherlands

Semiconductor and related ESDM industry bodies in India	**Year of establishment**
Electronics Industry Association of India	1967
VLSI Society of India	1990
Indian Cellular and Electronics Association	2002
India Electronics and Semiconductor Association	2004

Semiconductor R&D laboratories in India	**City located**
Microelectronics & MEMS Laboratory, Indian Institute of Technology (IIT) Madras	Chennai
Nanoelectronics Devices and Circuits Laboratory, IIT Gandhinagar	Gandhinagar
Wide Bandgap Semiconductor Laboratory, IIT Roorkee	Roorkee
Device Research Laboratory, IIT Roorkee	Roorkee
Semiconductor Device Fabrication Laboratory, IIT Kanpur	Kanpur
Nanofabrication Facility, IIT Bombay	Mumbai
Semiconductor Thin Film and Plasma Processing Laboratory, IIT Bombay	Mumbai
Nanophotonics Laboratory, IIT Hyderabad	Hyderabad
Department of Electronic Systems Engineering, Indian Institute of Science	Bengaluru
Department of Condensed Matter Physics & Material Science, Tata Institute of Fundamental Research	Mumbai
Centre for Materials for Electronics Technology	Hyderabad
Centre for Development of Advanced Computing	Bengaluru

Central Electronics Engineering Research Institute	Pilani
Central Scientific Instruments Organisation	Chandigarh
Semi-Conductor Laboratory	Chandigarh
Semiconductor Technology & Applied Research Centre	Bengaluru
Gallium Arsenide Enabling Technology Centre	Hyderabad
Solid State Physics Laboratory	New Delhi

As shown in Table 2 above, Dutch ESDM companies, especially those from the semiconductor sector, have minimal presence in India. This minimal presence has primarily been a sign of the absent semiconductor sector enabling policies and partnerships that would have enabled it. Regardless, some major Dutch ESDM companies have long been present in India and are vital contributors to the Indian semiconductor ecosystem.

NXP Semiconductors (formerly Philips Semiconductors), Europe's second-largest semiconductor company, has a significant presence in India's semiconductor design ecosystem.[21] Recently, NXP Semiconductors was among the sponsors of the 2022 'SemiconIndia' conference organised by the India Semiconductor Mission.[22] Philips has had a long presence in India through its domestic appliances business, since 1930, and it understands the Indian market well.[23] Some of this ground knowledge could be passed on to NXP Semiconductors. In 2021, the Dutch company NXP Semiconductors (India), along with MEITY's Startup Hub and the Fabless Chip Design Incubator at the IIT Hyderabad, initiated the Semiconductor Startup Incubation and Acceleration Program.[24] NXP Semiconductors, through this programme, will provide EDA tools to start-ups, give start-ups access to the ecosystem, mentor them, enable them with post-silicon laboratory access, and offer them their industry-experienced and ecosystem-exposed experts.

[21] Sanjay Gupta, 'We are NXP | NXP India Celebrates Its 'Tiny Scientists', *NXP*, 3 February 2021, accessed 21 December 2022, https://www.nxp.com/company/blog/we-are-nxp-nxp-india-celebrates-its-tiny-scientists:BL-NXP-INDIA-TINY-SCIENTISTS.
[22] Ministry of Electronics and Information Technology, 'SemiconIndia 2022', accessed 24 December 2022, https://www.semiconindia.org/.
[23] Elcoma India, 'History – Philips India Limited', accessed 24 December 2022, https://www.elcomaindia.com/?page_id=2406.
[24] Indian Institute of Technology Hyderabad, 'Fabless Chip Design Incubator', accessed 24 December 2022, http://fabci.iith.ac.in/fabci-nxp-sips-program.html#:~:text=Semiconductor%20Startup%20Incubation%20and%20Acceleration,IP%20design%20startups%20across%20India.

ASM Pacific Technology (ASMPT), a sister company of ASM International, has sales representation in India extending to neighbouring Bangladesh and Sri Lanka.[25] ASMPT will be a vital vendor in establishing fabs, OSAT and ATMP units.

Millux, a Dutch high-precision laser technology company that supplies its lasers to the semiconductor fabrication industry, is part of the Muon Group, based in Eerbeek.[26] The group also consists of India-based Atul Sugar Screens, Asia's largest manufacturer of nickel screens for the sugar-processing industry.[27] The Millux–Atul relationship through the Muon Group is one example of how high-precision ESDM components can serve diverse industries. This Millux–Atul exemplar also indicates Indian Prime Minister Narendra Modi's views on the health–agriculture–water trinity as the bedrock of India–Netherlands close mutual collaborations.[28]

India's MEITY and the Netherlands Organisation for Scientific Research (NWO) have supported collaborative R&D in convergence communications and broadband technologies on government-to-government bilateral research initiatives. Inopportunely, none of these projects are directly involved in semiconductor capacity-building, but some of these bilateral projects include:[29]

i. Digital Twin for Pipeline TRANSport Network;
ii. Personal Health Train for Radiation Oncology in India and the Netherlands;
iii. Data-Driven E-Commerce Order Fulfilment;
iv. Collaborative R&D Projects in Pervasive Communications & Computing.

Since 2018, India's Department for Promotion of Industry and Internal Trade, Invest India and Start-up India have created the #StartUpLink initiative with the Embassy of the Netherlands in India. Here, both India and the Netherlands have also identified medical technologies, agriculture technologies and cybersecurity as priority sectors for collaborations between their respective start-ups.[30]

[25] ASM Pacific Technology, 'Who we are', accessed 24 December 2022, https://www.asmpt.com/.
[26] Millux, 'Applications', accessed 24 December 2022, https://www.millux.nl/millux-applications/#semicon.
[27] Atul Sugar Screens, 'About', accessed 24 December 2022, https://atulscreens.com/.
[28] Ministry of External Affairs – Embassy of India, The Hague, Netherlands, 'India-Netherlands Bilateral Relations', *Government of India*, accessed 24 December 2022, https://indianembassynetherlands.gov.in/page/india-netherlands-relations/.
[29] Ministry of Electronics and Information Technology, 'International R&D Collaboration – Indo Dutch R&D Collaboration', accessed 24 December 2022, https://www.meity.gov.in/international-rd-collaboration.
[30] Startup India, 'Creating opportunities to navigate the Indian and Dutch startup ecosystems', Government of India, accessed 25 December 2022, https://www.startupindia.gov.in/content/sih/en/international/indo-dutch.html.

Semiconductor manufacturing capabilities are crucial for India's self-reliance (*Aatmanirbhar Bharat*) goals for its comprehensive national security, regional technological leadership, digital sovereignty, industrial growth and for ensuring skilling and employment for its large and skilled young population.

3. International positioning and connections

India is taking multifarious steps to incentivise ESDM companies operating in both pre-silicon and post-silicon domains. At present, India can be considered to be expediently positioned in pre-silicon domains, with numerous top-notch US, European, Asian and even home-grown fab-less and integrated device manufacturers (IDM) companies having large presence in the domestic ecosystem. Yet even the domestic IDMs are engaged largely in design and are deficient on the manufacturing side. India's semiconductor fabs have largely been run by the central government and have thus been working primarily in space, aerospace and defence domains. Nonetheless, India in the past few years had realised the limitations of its ESDM capabilities.

Although India has a formidable share in global semiconductor design capacities, many Asian countries have substantial pre-silicon ecosystems, nearly similar in strength with that of India. New Delhi understands that it has been heavily dependent on Asian countries for assembly, testing and manufacturing. Precisely because of this dependence, India intends to evolve its own manufacturing/ATMP/OSAT ecosystem, which will in turn also strengthen India's semiconductor design competencies.

With PLIs for mobile phones, large-scale (consumer) electronics, IT hardware and electronic manufacturing clusters, the Indian government has attracted numerous original design manufacturers (ODMs) and OEMs from China, Japan, Taiwan, Europe and North America, to establish manufacturing facilities in India under the 'Make in India, Make for World' campaign. This electronics assembly ecosystem would naturally become a bedrock market for fabs and semiconductor OSAT/ATMP units, especially with overseas investments for the massive market in the Indo-Pacific. To this end, India has begun to identify strategic semiconductor partners.

Through the Foxconn–Vedanta partnership, India and Taiwan are investing in a multi-billion dollar 28nm node giga fab. This fab's output is bound to reduce India's imports and create new jobs and a massive exports market, especially in West, South, South-East and Central Asia, Africa and Oceania. Furthermore, the 28nm node caters to applications from consumer electronics, smart phones, computing, automotive, the Internet of Things, graphic processing and high-speed networking chips. Therefore, the approximately 8 billion USD investment will seemingly give a reasonable internal rate of return. Furthermore, Foxconn–Vedanta's success with the 28nm node will encourage subsequent international investments on other nodes, especially those with 24nm and lower nodes. For Taiwan, such investments will moreover reduce its overdependence on China, from the globally strategic semiconductor industry standpoint.

Furthermore, it is well acknowledged that the global semiconductor industry is siloed in a few countries, and any geopolitically crucial conflict may disrupt the global semiconductor supply chain. The world is looking forward to diversifying global semiconductor supplies, and especially to building manufacturing capacities in politically and economically stable countries. India suits this requirement.

Taiwan's TSMC is one of the three large pure-play semiconductor companies, along with Intel and Samsung. These are the only three companies likely to set up giga fabs in India, but Intel and Samsung have yet to make a decision. This leads to a scenario where India is actually *less* likely to house several multi-billion dollar giga fabs through foreign partnerships, regardless of the incentives offered. For the same reason, India may look into establishing numerous ATMP and OSAT plants, which are fiscally prudent options and each plant could cater to one or more applications. For example, the Tata Group, India's leading automobile manufacturer, and Renesas (Japan) have entered a strategic partnership and could soon set up an OSAT plant, worth less than 500 million USD, catering exclusively to automotive semiconductors.[31]

India's geopolitical positioning is not only limited to being a high-tech manufacturing hub, but an exporter of high-tech goods along the International North–South Transport Corridor, the Asia–Africa Growth Corridor and the India–Israel–United States–United Arab Emirates trade routes.

[31] 'Renesas Partners with Tata to accelerate progress in advanced electronics for India and Emerging Markets', *Renesas*, 29 June 2022, accessed 25 December 2022, https://www.renesas.com/tw/en/about/press-room/renesas-partners-tata-accelerate-progress-advanced-electronics-india-and-emerging-markets-0.

India may not demarcate its alignment in the ongoing US–China Chip War but may instead simply leverage its inherent strengths. India's robust national and regional security architecture, forthcoming diplomatic outreach and strategic location along trade corridors make it a suitable base for global ESDM companies. India is consciously framing policies around its 2070 net zero commitments from COP26 in November 2021. This has begun attracting environmental, social and governance (ESG)-conscious sovereign wealth funds.

India's PLI schemes and the India Semiconductor Mission will together become a cornerstone of the strong economic indicators that are forecasted for India in the foreseeable future.

4. Implications for the Dutch sector

The role of the Dutch semiconductor industry in the India Semiconductor Mission will be essential. The Vedanta–Foxconn Giga fab and other smaller pure-play mega fabs, ATMP and OSAT units will likely become a new market opportunity for the global photolithography giant, ASML Holdings.

India's semiconductor ecosystem has a strong US imprint, primarily through the design and R&D units of big fabless firms located in India. There is therefore less likelihood of the US imposing sanctions concerning sales of ASML lithography units to India-based companies, just as the US attempts to do with China through the CHIPS and Science Act.[32] India is a cost-conscious market and manufacturers may avail themselves of the services of any other lithography instrument manufacturer that offers their technology at competitive prices. ASML Holdings may therefore find competition if its competitors pursue an aggressive pricing strategy in India.

India's and the Netherlands' semiconductor ecosystems are distant, with minimal business happening between them. Very few Indian and Dutch small and medium enterprises from the semiconductor ecosystem deal with each other. There are thus numerous opportunities to acquire stakes in each other's entities and grow in each other's ecosystems.

India's largest employment sector exists among its micro, small and medium-scale enterprises (MSMEs). South Korea, the United States, Japan and Taiwan have made strong bilateral connections

[32] 'Fact Sheet: CHIPS and Science Act will lower costs, create jobs, strengthen supply chains, and counter China', *The White House*, 9 August 2022, accessed 25 December 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.

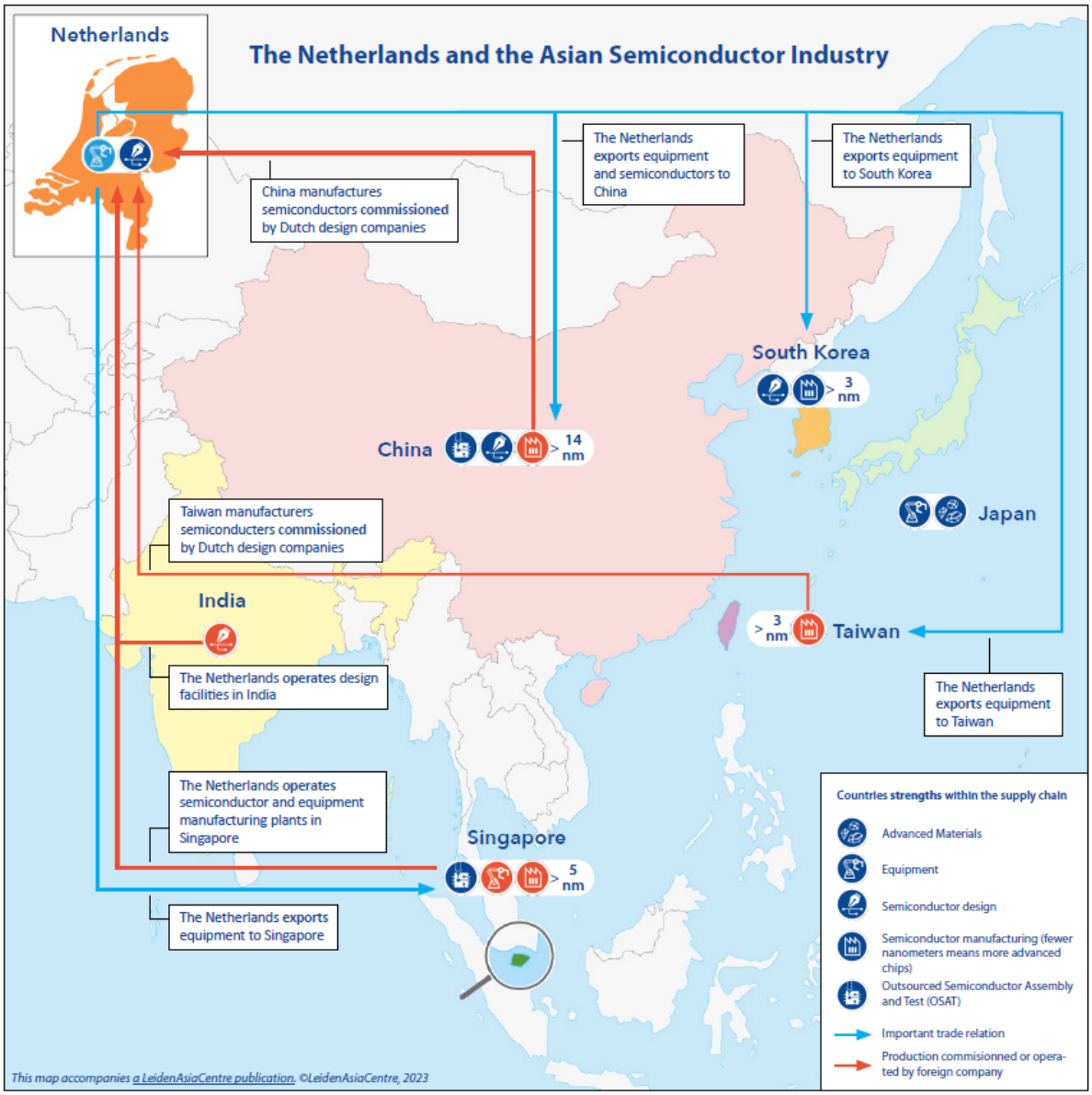
with India's lucrative MSME sector. In waiting for large Dutch businesses to do impactful business in India, and vice versa, the Dutch and Indian governments might be losing out on numerous opportunities that could be quickly realised if Indian and Dutch MSMEs engaged more with each other. These possibilities also include Dutch companies partnering in small, Indian pure-play fabs, OSAT and ATMP units and utilising India's various incentives.

NXP Semiconductors was present at the 2022 'SemiconIndia' conference. Nevertheless, the Dutch Embassy in India and Indian Embassy in the Netherlands must ponder why the Netherlands' foremost semiconductor industry organisation, Holland Semiconductors,[33] or any of its partner industry bodies, participate in this conference or even in other activities of the India Semiconductor Mission. Thoroughly knowing the Dutch semiconductor ecosystem's strengths, the Indian ecosystem's potential and the strong India–Netherlands bilateral trade, the #StartUpLink has also not initiated a dedicated programme for nurturing semiconductor start-ups. Overall, there is tremendous untapped potential in the India–Netherlands semiconductor partnership, which is going unused because of limited interactions between their start-ups and MSMEs.

Protectionist tendencies in the European Union and the United States impede the Dutch industry's expansion into new and strengthening semiconductor manufacturing markets such as India. A low degree of business relations in India will likely make protectionist tendencies effective. On the other hand, more comprehensive bilateral semiconductor businesses and stakes in each other's MSMEs and start-ups are likely to deter such tendencies. Indian and Dutch semiconductor ecosystems must explore newer business opportunities, build new and resilient supply chains, and create a solid bilateral niche within the global semiconductor industry. The already strong Indo-Dutch trading relations should be leveraged further.

[33] Holland Semiconductors, 'Internationalisation', accessed 25 December 2022, https://hollandsemiconductors.nl/.

Map of Dutch semiconductor interests in Asia



For an interactive version of this map, visit: https://leidenasiacentre.nl/map-of-dutch-semiconductor-interests-in-asia