ASEAN Investment Report 2020–2021

Investing in Industry 4.0

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one identity
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ASEAN Investment Report 2020–2021

Investing in Industry 4.0

The ASEAN Secretariat

United Nations Conference on Trade and Development

The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967. The Member States are Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

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The map in this publication is only indicative and is not drawn to scale.

Disclaimer

The ASEAN Investment Report is produced to facilitate a better understanding of FDI developments in ASEAN. The findings, interpretations, and analysis in the Report should be treated with care, as work on harmonising and improving FDI quality across the region is on-going.

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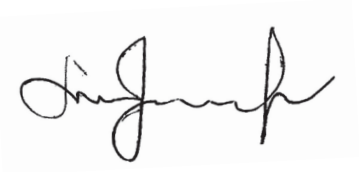
FOREWORD

Foreign Direct Investment (FDI) inflows into ASEAN reached its highest ever level in 2019 at US$ 182 billion, making ASEAN the largest recipient of FDI in the developing world. Due to the unprecedented impact of the COVID-19 pandemic, FDI declined to US$ 137 billion in 2020, which is quite significant, but compared to the decline of global FDI level, ASEAN still performed slightly better as its share of global FDI actually rose from 11.9 per cent in 2019 to 13.7 per cent in 2020. FDI in the digital economy sectors and infrastructure-related industries helped to cushion the fall of FDI in other sectors in the wake of the pandemic. Investment within the region remained resilient, increasing by 5 per cent to $23 billion in 2020, pushing up the intra-ASEAN share of FDI in the region from 12 to 17 per cent.

During this period, ASEAN and its five Free Trade Agreement (FTA) partners concluded negotiations and signed the Regional Comprehensive Economic Partnership (RCEP) Agreement in November 2020. This mega regional trading agreement, which constitutes about 15 per cent of global FDI stock and more than 33 per cent of global FDI flows in 2020, is expected to provide an opportunity for ASEAN and its partners to further boost investment and enhance the development of the global value chain in the region.

This year's *ASEAN Investment Report* features the role of FDI and Multi-National Enterprises (MNEs) in Industry 4.0 transformation in the region, and how ASEAN Member States promote the adoption of Industry 4.0 technologies to support their industrialisation and enhance overall economic competitiveness. The Report also provides recommendations going forward to address the challenges in attracting FDIs to support this transformation process, noting that the prospects for FDI in Industry 4.0 relevant industries and activities are positive.

In the wake of the pandemic, accelerating digitalisation and Industry 4.0 transformation can go hand-in-hand with attracting FDIs in rebuilding the ASEAN economy. We hope that policy makers and stakeholders in the industry will find the Report useful in this endeavour.



Dato Lim Jock Hoi
Secretary-General of ASEAN

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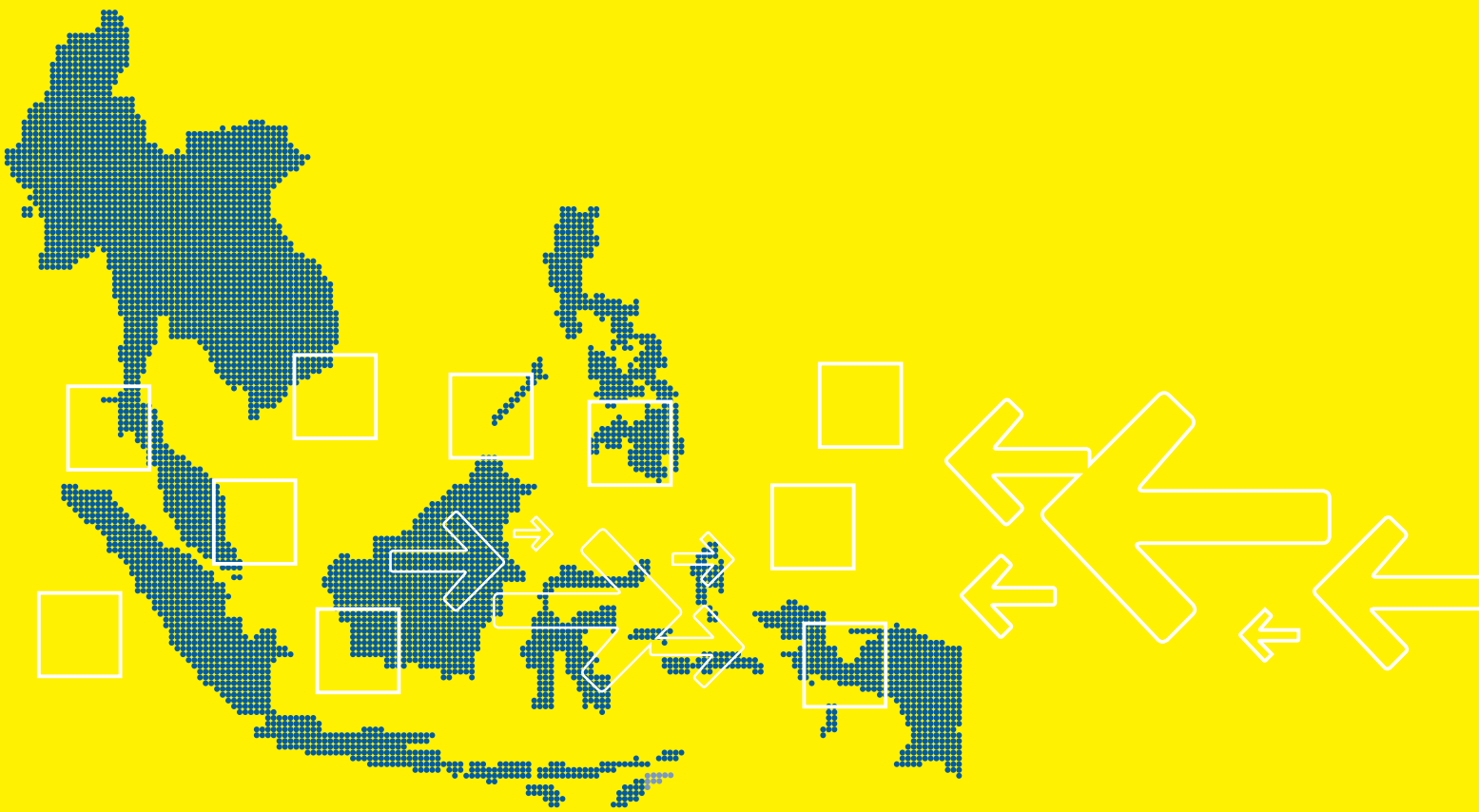
ABBREVIATIONS

AANZFTA	ASEAN–Australia–New Zealand Free Trade Agreement
ACIA	ASEAN Comprehensive Investment Agreement
ACTS	ASEAN Customs Transit System
ADB	Asian Development Bank
AEC	ASEAN Economic Community
AFAS	ASEAN Framework Agreement on Services
AFTA	ASEAN Free Trade Area
AI	artificial intelligence
AIR	ASEAN Investment Report
AM	additive manufacturing
ASW	ASEAN Single Window
ATIGA	ASEAN Trade in Goods Agreement
ATISA	ASEAN Trade in Services Agreement
AWSC	ASEAN-Wide Self-Certification
BIT	bilateral investment treaty
BPO	business process outsourcing
CAGR	compound annual growth rate
CLMV	Cambodia, Lao People's Democratic Republic, Myanmar, Viet Nam
EPC	engineering-procurement-construction
EU	European Union
FDI	foreign direct investment
FTA	free trade agreement
GDP	gross domestic product
GVC	global value chain
IA	industrial automation
ICT	information and telecommunication technology
IIoT	industrial internet of things
IoT	internet of things
IPA	investment promotion agency
IPF	international project finance
ISDS	investor–State dispute settlement
IT	information technology
LDC	least-developed country
M&A	merger and acquisition

MNE	multinational enterprise
MSMEs	micro, small and medium-size enterprises
MW	megawatt
OEM	original equipment manufacturer
OFDI	outward foreign direct investment
PPE	personal protective equipment
PPP	public-private partnership
R&D	research and development
RCEP	Regional Comprehensive Economic Partnership
SARS	Severe acute respiratory syndrome
SEZ	special economic zone
SMA	Southeast Asia Manufacturing Alliance
SMEs	small and medium-sized enterprises
STEM	science, technology, engineering and math
SWF	Sovereign wealth fund
TIP	treaty with investment provisions
TRIMS	Trade-Related Investment Measures
UNCTAD	United Nations Conference on Trade and Development
WIR	World Investment Report
WTO	World Trade Organization

OVERVIEW



OVERVIEW

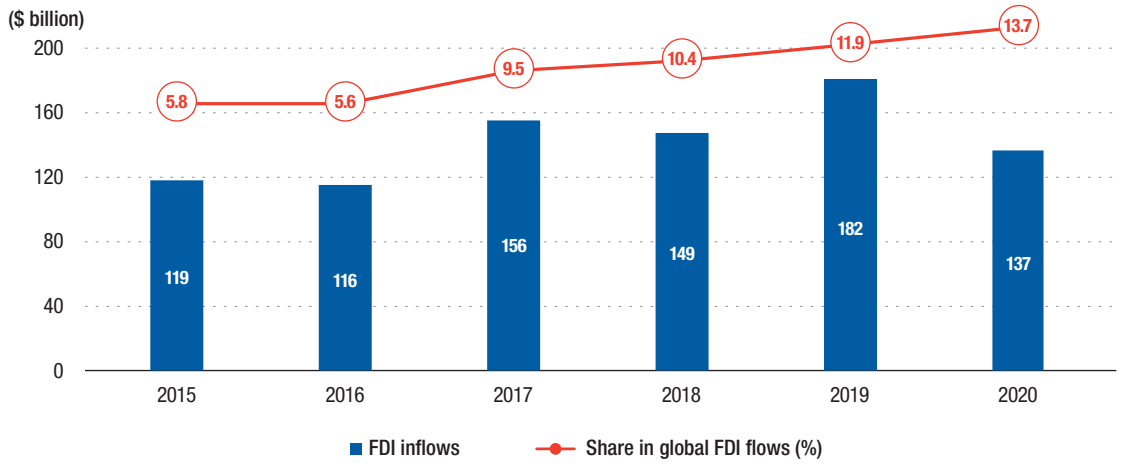
FDI AND CORPORATE INVESTMENT TRENDS

The past two years (2019 and 2020) were exceptional for ASEAN in terms of foreign direct investment (FDI): 2019 saw the region's highest-ever inflows, at $182 billion – making ASEAN the largest recipient of FDI in the developing world – and 2020 saw the unprecedented impact of the COVID-19 pandemic, with a 25 per cent fall in FDI, to $137 billion (figure 1). The decline followed lockdown measures, supply chain disruptions, falling corporate earnings, successive waves of the pandemic, economic uncertainty and postponement of investment by multinational enterprises (MNEs).

Investment activity in the region shrank across all types. Announced greenfield investment declined by 17 per cent to $68 billion, international project finance fell by 21 per cent to $53 billion, and cross-border mergers and acquisitions (M&As) recorded a precipitous dive from $9.8 billion in 2019 to -$4.7 billion.

Despite the decline, ASEAN remained an attractive investment destination; the region's share of global FDI rose from 11.9 per cent in 2019 to 13.7 per cent. FDI inflows remained more than twice the amount seen during the 2007–2008 global financial crisis and nearly five times more than the annual average during the 2002–2004 outbreak of SARS (severe acute respiratory syndrome).

Figure 1. FDI inflows in ASEAN and share in world total, 2015–2020 (Billions of dollars and per cent)

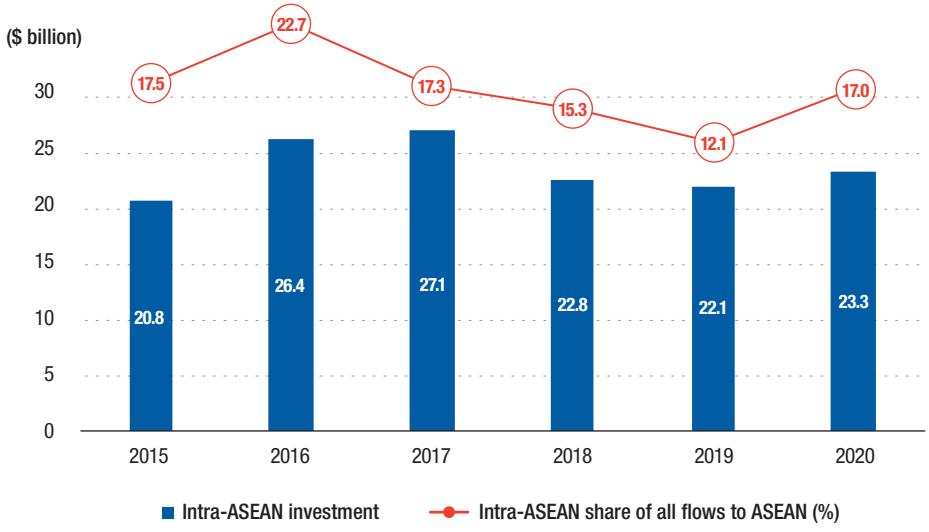


Source: UNCTAD and ASEAN Secretariat.

The pandemic affected most Member States, with seven seeing a drop in investment. Brunei Darussalam and the CLMV (Cambodia, the Lao People's Democratic Republic, Myanmar and Viet Nam) countries were relatively resilient, with either an increase in investment or a small change in inflows.

Investment from most of the top 10 source countries, which accounted for 75 per cent of FDI in ASEAN in 2020, fell. **Investment within ASEAN was resilient, rising by 5 per cent to $23 billion, pushing up the intra-ASEAN share of FDI in the region from 12 to 17 per cent** (figure 2). A significant portion of such investment originates from outside the region and is channelled through a few Member States. Such conduit investment involves ultimate owners from outside the region.

Figure 2. Intra-ASEAN investment flows and shares, 2015–2020 (Billions of dollars and per cent)



Source: ASEAN Secretariat, ASEAN FDI database.

Most industries other than those in infrastructure and digital economy sectors saw FDI fall. FDI in manufacturing contracted by 55 per cent, from $49 billion in 2019 to $22 billion – a key contributor to the overall decline. FDI also faltered in services industries such as finance, hospitality, tourism, real estate and construction. Yet, investment rose in infrastructure-related industries such as electricity and in information and communication as well as transportation and storage – underscoring the resilience of these industries in an economically challenging time. FDI in wholesale and retail trade declined marginally, by 5.6 per cent, to $26.5 billion – still a high level – sustained by continued growth in digital technologies, e-commerce and online activities. Strong investment in the digital economy, the roll-out of 5G licences and active investment in data centres and cloud computing, including relocation of factories to some Member States, helped to cushion the fall to some extent.

ASEAN remains an important destination for international project finance activities, mostly in infrastructure. Despite the 2020 fall, the longer-term trend, comparing 2015–2017 and 2018–2020, is encouraging. Values of international project finance in ASEAN nearly doubled between the two periods, from an annual average of $37 billion in 2015–2017 to an annual average of $74 billion in 2018–2020. The region's share of such activities worldwide rose from 7.9 per cent in 2015–2017 to 12.5 per cent in 2018–2020. Asia, the largest destination for international project finance, accounted for nearly 40 per cent of global values in 2018–2020, and ASEAN accounted for 32 per cent of Asia's share.

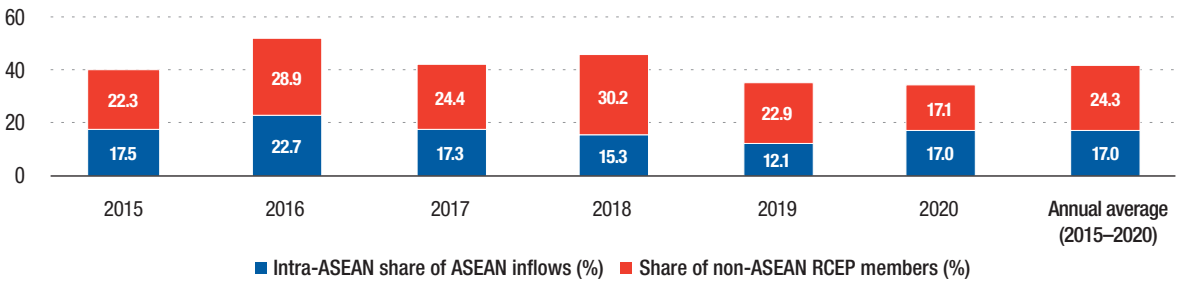
MAJOR DEVELOPMENTS SHAPING THE FDI LANDSCAPE AND POST-PANDEMIC RECOVERY

RCEP

The Regional Comprehensive Economic Partnership (RCEP) group is an important and growing source of global FDI. Intraregional investment, at about 30 per cent of total FDI in RCEP, has significant room for further growth. About 15 per cent of global FDI stock and more than 33 per cent of global flows in 2020 were in RCEP members. Growing annual inflows pushed up FDI stock in the group from $2.7 trillion in 2010 to $6.2 trillion in 2020, an average growth rate of 9 per cent per year. In outward FDI, the group accounted for 48 per cent of global flows in 2020, up from just 17 per cent in 2010. The rise pushed up the stock of outward FDI, from $2.4 trillion in 2010 to $7.1 trillion in 2020 – more than twice the growth rate of global outward FDI stock in the same period.

ASEAN, at the heart of the RCEP, will play an important role in the group. Already about 40 per cent of investment in ASEAN comes from RCEP members, of which 24 per cent comes from non-ASEAN RCEP member countries (figure 3). There are opportunities for greater connectivity through investment, production and intrafirm transactions in ASEAN and between ASEAN and non-ASEAN RCEP members.

Figure 3. RCEP members share of FDI in ASEAN, 2015–2020 and annual average, 2015–2020 (Per cent)



Source: ASEAN Secretariat, ASEAN FDI database.
Note: Non-ASEAN RCEP members refer to Australia, China, Japan, Republic of Korea and New Zealand.

The RCEP increases ASEAN's attractiveness for FDI, value chain activities and international production. It provides investors an opportunity to operate in ASEAN with access to the world's largest market. Major provisions of the RCEP Agreement address liberalizing and promoting intra-RCEP trade, investment and services as well as developing e-commerce, which is highly relevant for regional value chains and market- and efficiency-seeking investment. The top 100 MNEs from non-ASEAN RCEP member countries are all present in ASEAN. They hold more than $1.1 trillion in cash or near-cash items and $13.6 trillion in assets in 2019, an indication of their significant investment firepower and potential for new, expansion and diversification activities.

Relocations and GVC resilience

Relocation of production to ASEAN is not new; however, now MNEs are not relocating just for cost reasons. Influencing the decision are a mix of additional factors, including geopolitical and supply chain resilience considerations. MNEs' diversification of production from China to ASEAN countries was originally driven by rising costs in China. The trade tensions between the United States and China accelerated the process, including for Chinese companies. The disruption of supply chains during the pandemic is a further motivation. Home-country policy measures that encourage diversification of supply chains are also encouraging firms to move operations or reshore away from China to neighbouring countries – making ASEAN Member States target destinations.

Infrastructure investment push

Since the pandemic, ASEAN Member States have accelerated the push for investment in infrastructure, facilitated by ambitious national infrastructure plans, policy measures and greater opportunities for private sector participation. The infrastructure investment need in the region is huge, estimated to be between $110 billion and $184 billion annually during 2015–2030. This estimate covers mostly transport, power and telecommunication. MNEs and foreign investors have been contributing to infrastructure development in the region through various channels: sponsoring; financing; providing engineering, procurement and construction (EPC) services and technology; and supplying equipment.

Growth of Chinese FDI and MNE activities

ASEAN has seen robust investment from China in the last decade through both equity and non-equity modes such as international infrastructure contracts. In some Member States (e.g. Cambodia and the Lao People's Democratic Republic), FDI from China has constituted the largest source of investment for consecutive years. FDI from China rose by 65 per cent over the past decade, from an annual average of $6.9 billion in 2011–2015 to an annual average of $11.5 billion in 2016–2020, pushing up the country's share in total FDI in ASEAN from 6.2 per cent to 7.9 per cent. ASEAN accounted for only 5.0 per cent of the global outward FDI stock of China in 2019, up from 4.5 per cent in 2010.

But rising Chinese investment in ASEAN pushed the region's share of outflows from China from an average of 5.5 per cent in 2009–2010 to an average of 9.0 per cent in 2018–2019.

Within Asia, ASEAN is the largest target destination for Chinese international infrastructure contracts. In 2017–2019, some 22 per cent of such contracts were in ASEAN, underscoring the importance of Chinese MNEs in infrastructure development. Most contracts were in transportation, power and telecommunication, and many were identified as related to the Belt and Road Initiative.

Prospects

The outlook for FDI in ASEAN in 2021 is promising because of improving national and global economic growth and strong efforts by Member States to attract FDI. Many reported an increase in FDI in the first quarter of 2021 as compared with the last quarter of 2020. However, much will depend on how well countries in the region are able to contain the new wave of the pandemic unfolding in 2021. UNCTAD has projected an increase of FDI flows to Asia in 2021 of between 5 and 10 per cent, with ASEAN playing an important role, underpinning growth prospects for the wider region.

A number of key developments will help the region turn around. First, Member States have continued to implement economic stimulus packages to bolster resilience and have adopted measures favourable to FDI, including implementation of the 2020 ASEAN Comprehensive Recovery Framework. Second, during the pandemic some industries strove to increase their online activities, in e-commerce and the digital economy. These industries will continue to attract investor interest. ASEAN Member States also continued to push for digital infrastructure development (5G networks and data centres) and private investment in these areas, including cloud computing. FDI in these areas is expected to remain robust. The region is projected to become a rapidly growing global data centre market in the next five years, overtaking the growth in North America and in Asia-Pacific countries outside ASEAN. Many data centre and cloud MNEs are increasing their investment or building more facilities, driven by the rapidly growing digital economy and the push for Industry 4.0 transformation in the region.

Member States are also further accelerating the development of physical infrastructure (e.g. transportation, telecommunication, power and special economic zones (SEZs)) and actively promoting private sector participation, including FDI. This push will help attract investment and strengthen the investment environment through the development of more and better infrastructure.

FDI POLICY ENVIRONMENT IN ASEAN

The investment policy environment in ASEAN continued to improve, with adoption of more regional and national investment-related measures in 2018–2020, mostly favourable to FDI. These and investment measures adopted before 2018 have contributed to the growing attractiveness of the region for investment.

The unprecedented events of 2020 brought a surge in adoption of investment measures by Member States – at regional and national levels – to help businesses mitigate the impact of the pandemic and to promote economic recovery.

At the regional level, more than 14 major agreements or initiatives were adopted in 2018–2020 that have implications for the region's investment environment. They aim to strengthen digital cooperation and improve the ease of doing business and investing in the region. Regional agreements included the improvement of the ASEAN Comprehensive Investment Agreement, a new ASEAN Trade in Services Agreement, and actions to strengthen cooperation for the development of the digital economy, smart cities, and e-commerce and for Industry 4.0 transformation. Some regional initiatives supporting customs integration and cooperation to facilitate the movement of goods within the region were implemented during the period (e.g. the ASEAN Trade in Goods Agreement e-form to access preferential tariff rates and the ASEAN-wide self-certification scheme for intraregional movement of goods). In addition, the ASEAN Comprehensive Recovery Framework was adopted; it provides a coordinated strategy and measures focused on key sectors for post-pandemic recovery, including attracting FDI.

At the national level, Member States continued to introduce measures to attract FDI. They implemented a wide range of FDI-related measures, which covered liberalization, relaxation of investment conditions, facilitation and promotion. There were a few regulatory or restrictive measures. They covered data protection requirements and cybersecurity in 2019 and export restrictions on medical and essential products in 2020 (quickly lifted through regional cooperation). Most measures favourable to FDI aimed at lowering transaction or business costs, improving the investment environment, simplifying investment processes, relaxing investment conditions and granting investment incentives. Member States continued to support investment in the development of major infrastructure, including the establishment of SEZs.

Pandemic response measures

In 2020, Member States adopted more than 50 measures favourable to investment, as compared with 29 in 2018 and 27 in 2019. **Many business and investment measures related to the pandemic were offered to support investors.** They were mostly investment facilitation and promotion measures to support, attract and retain investment. These measures granted investment incentives; simplified procedures; reduced business costs; extended deadlines for tax, duties and utility payments; and offered special assistance to help investors.

Member States introduced series of national stimulus packages. **They also cooperated, agreeing not to impose export restrictions and to facilitate the smooth flow of supply chains and sourcing in the region**, particularly on essential goods. This was crucial, as much of FDI in ASEAN is connected to global value chain (GVC) activities or regional production networks that involve intra- and inter-firm linkages.

Supply chain diversification measures

Some Member States adopted specific measures to attract and facilitate relocation or diversification of supply chain investments. Among other measures, they offered special investment incentives for a specific period, set up special task forces to facilitate relocation activities, simplified investment processes and provided support with access to SEZ facilities.

RCEP Agreement

A major development in extraregional FTAs was the signing of the RCEP Agreement in 2020. The investment chapter of the Agreement includes the following key elements, which have important implications for FDI:

(i) Most-favoured-nation treatment and commitments related to the prohibition of performance requirements that go beyond the World Trade Organization (WTO) Trade-Related Investment Measures Agreement

(ii) National treatment, fair and equitable treatment, direct and indirect expropriation clauses and free transfer of funds

(iii) A schedule of reservations and non-conforming measures using the negative-list approach

(iv) Investment promotion and facilitation provisions, which address simplification of investment approval procedures, investment assistance and provision of advisory services and information

The RCEP has the potential to help Member States attract intraregional investment, FDI and GVC activities. The Agreement contains measures in key areas such as market access, economic cooperation, and rules and disciplines (table 1). The specific provisions on investment could enhance investment opportunities in the long term, but the provisions related to trade in goods and services, intellectual property and e-commerce could help to increase flows of investment in the short term by facilitating the exchange of goods and services, and by lowering transaction costs for business. Although the Agreement promotes intra-RCEP trade, investment and services, non-RCEP companies can also take advantage of RCEP benefits by locating and operating in the region.

Table 1. RCEP Agreement: Implications for FDI

Key areas	Provisions most relevant for international investment
Investment	Consolidation of existing market access (as contained in myriad bilateral agreements) Negative-list approach for investment entry; framework for future liberalization efforts Investment facilitation (transparency and streamlining of administrative procedures for investors) Core investment protection and non-discrimination provisions (investor–State dispute settlement (ISDS) not included
Trade in goods	Consolidation of tariff reduction or elimination schedules, single set of rules of origin (a major advancement in regional integration), facilitating trade in regional value chains Trade facilitation (rules for custom procedures, technical standards and non-tariff measures; promotion of transparency and cooperation)
Trade in services	Market access for service suppliers and enhanced transparency and rules affecting services trade Enhanced rules for cross-border supply of financial and telecommunication services to facilitate regional business operations Reduced barriers to cross-border supply of professional services and framework for recognition of professional qualifications and licences
E-commerce	Enhanced rules governing cross-border supply and use of telecommunication services Digital trade facilitation (promotion of digital documentation, electronic signatures) No comprehensive coverage of cross-border data flows and localization requirements, but reduced scope for new restrictions
Other rules and disciplines	Facilitation of cross-border movement of businesspeople Standardized rules to streamline intellectual property transactions Common rules on government procurement
Economic cooperation	Capacity-building and technical assistance to support implementation of the agreement Programmes to enhance the capability of small and medium-size enterprises (SMEs) to benefit from the agreement

Source: UNCTAD, *Investment Trends Monitor*, Special Edition, "RCEP Agreement a potential boost for investment in sustainable post-COVID recovery", November 2020.

International investment agreements

ASEAN has one of the highest numbers of international investment agreements (IIAs). As of April 2021, ASEAN Member States had signed 221 treaties with investment provisions (TIPs) under the free trade agreement (FTA) framework and 287 bilateral investment treaties (BITs) with non-ASEAN Member States. Between 2011 and April 2021, the number of TIPs signed by ASEAN Member States rose by 36 per cent and BITs with non-ASEAN countries by 10 per cent. In 2018–2020, ASEAN Member States concluded 10 bilateral TIPs. These large numbers of IIAs (TIPs and BITs) underscore the Member States' commitment to attracting FDI and strengthening investment relationships with partner economies.

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Action plans to realize the objectives of the ASEAN Economic Community 2025, ASEAN-plus-one FTAs and the RCEP Agreement need to be implemented efficiently, following agreed schedules and time frames. Although national actions to attract, retain and facilitate FDI play a catalytic role in improving the region's attractiveness for cross-border investment, Member States should avoid competing on incentives. Cooperation can be strengthened further by building more resilient supply chains and a more efficient logistics infrastructure,

and facilitating FDI in GVC activities on the basis of the benefits of regional division of labour. A stronger institutional mechanism involving relevant host-country and home-country agencies could be considered for this purpose.

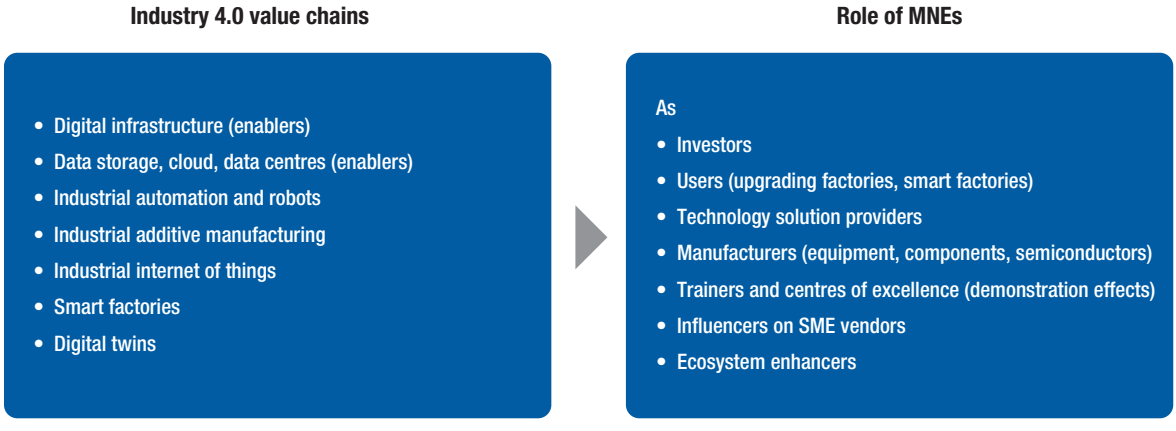
FDI AND MNEs AND INDUSTRY 4.0 TRANSFORMATION IN ASEAN

All ASEAN Member States recognize the importance of Industry 4.0, or the 4th Industrial Revolution, for advancing economic development and industrial transformation and ensuring continued effective participation in GVCs. They also recognize the role that the private sector can play in Industry 4.0 transformation.

Foreign investors in ASEAN are playing an important catalytic role in the Industry 4.0 transformation process as users, technology providers, manufacturers, trainers, influencers of SMEs, and ecosystem enhancers (figure 4). They are investing in digitalization of manufacturing, using advanced manufacturing solutions, building smart factories and establishing research and development (R&D) facilities, technology hubs and centres of excellence in the region. Many have established a significant presence in the region to build digital infrastructure, manufacture industrial automation (IA) hardware and supply technologies to clients in the vibrant manufacturing environment and the rapidly growing regional digital economy. Many have also upgraded or plan to upgrade their factories with Industry 4.0 technologies.

The presence of many MNEs operating in key segments of Industry 4.0 technologies in ASEAN (e.g. 5G, data centres, IA, additive manufacturing, the industrial internet of things (IIoT) and smart factories) **is a testament to the growing significance of the region for FDI in Industry 4.0 activities.**

Figure 4. Role of MNEs in Industry 4.0 value chains



Source: ASEAN Investment Report 2020–2021 research, based on analysis of chapter 3.

Subsidiaries of MNEs are often better equipped to adopt Industry 4.0 technologies than are local companies because of their relatively stronger financial and technological capacities, and the influence of their parent companies' adoption of technology. MNE demonstration effects are encouraging other companies (local and foreign) to adopt Industry 4.0 technologies, especially SMEs that have vendor relationships with MNEs.

Investment in digital infrastructure

ASEAN countries have rolled out 5G contracts to build more efficient communication networks and digital infrastructure to form the backbone supporting Industry 4.0 development. Most Member States have already conducted or started trials of networks.

The investment needs for 5G infrastructure in ASEAN are significant, estimated at about $14 billion in annual capital expenditure between 2020 and 2025 to upgrade telecommunication facilities, networks and equipment to 5G requirements. Telecommunication MNEs from Asia (China, the Republic of Korea, Japan) and Europe are major 5G players in the region, primarily through contractual arrangements. Some are involved in multiple 5G development contracts in the same host country and in multiple countries across the region. These MNEs include Ericsson (Sweden), Huawei (China), Nokia (Finland), NTT (Japan) and ZTE (China), as well as regional players (e.g. Axiata (Malaysia), Singtel (Singapore), True Corporation (Thailand) and Viettel (Viet Nam)).

The region is projected to be one of the world's fastest-growing data centre markets in the next few years, exceeding the growth in North America and the rest of Asia-Pacific. Investment in data centres and cloud services has been increasing rapidly in ASEAN in recent years. The data centre market in ASEAN was worth $1.9 billion in 2019 but is expected to grow to $3.5 billion by 2024, at a compound annual growth rate of 13 per cent. In 2020, ASEAN hosted more than 295 data centres. In perspective, ASEAN accounts for 23 per cent of all data centres in member countries of the RCEP. Some 70 per cent of those are concentrated in three ASEAN Member States: Singapore, Indonesia and Malaysia.

More than 40 per cent of data centres in ASEAN are foreign owned or involve joint ventures. Many major MNEs that provide data centres and cloud services are present in ASEAN. Twelve of the 15 largest data centre MNEs, which account for 50 per cent of the global market, and all but one of the top 15 global cloud MNEs are establishing and operating data centres in the region.

These digital enablers permit efficient deployment of Industry 4.0 technologies and make possible greater digitalization of supply chains. They will accelerate digitalization and Industry 4.0 transformation in ASEAN. An industry report claims that enhanced connectivity and application of Industry 4.0 technologies are expected to generate $140–150 billion in additional revenue potential across key industries (agriculture, services and manufacturing) for ASEAN by 2025. The upgrade to 5G alone is expected to increase the additional revenue potential by 40 to 50 per cent. The manufacturing industry will be a major beneficiary through digital applications.

FDI and MNEs in additive manufacturing

The market for additive manufacturing (AM) technology and equipment in ASEAN is small but expected to grow rapidly over the next five years and beyond. AM spending in ASEAN was estimated at about $266 million in 2019 and is projected to reach $100 billion by 2025. In perspective, that is about 5–7 per cent of Asia's AM market of $3.8 billion in 2019. By 2025, the AM market in ASEAN is expected to be about one third the size of the combined digital economy market of the six largest economies in the region. This growth in demand, coupled with government policy and institutional support and other factors (e.g. the improving AM ecosystem in some Member States) has led to the growing presence of AM MNEs in ASEAN. The pandemic has also accelerated the adoption of AM technology in some countries.

Many MNEs have established regional headquarters, centres of excellence and R&D centres in the region to further develop industry-specific AM applications or to develop them for use in other industries. Some MNEs and local companies also develop the use of alternative materials for 3D printing. AM MNEs in ASEAN can be identified as equipment manufacturers, solutions providers and industrial users.

ASEAN is host to an increasing number of global AM providers. They include major AM MNEs headquartered in Europe (EOS, Thyssenkrupp, Siemens Digital Industries (all Germany), Materialise (Belgium), Renishaw (United Kingdom)), Japan (Matsuura, Mitsubishi Electric, Yamasaki Masak) and the United States (Autodesk, 3D Metalforge, HP and GE Additive). Many have established collaboration with host government agencies, research institutions, industry associations and other companies in supporting the development of the AM industry.

The presence of an efficient AM ecosystem or cluster is a key determinant for attracting FDI in AM activities. Some ASEAN Member States provide institutional support and investment incentives and are developing industrial facilities to attract advanced manufacturing activities, including in AM.

FDI and MNEs in industrial automation

Investment in activities related to IA in ASEAN is small. Announced greenfield investment in such activities has been flat at an annual average of $11 billion in both 2010–2014 and 2016–2020. Such investment accounted for about 12 per cent of total greenfield investment in ASEAN in the last decade. However, there is room for FDI in IA to grow. This is because the demand for automation and the IIoT in ASEAN is rising as more factories are moving towards digitalization and upgrading production facilities. The market for equipment and solutions for IA and process control in ASEAN is expected to grow at about 8 per cent per year from 2019 and reach $5 billion by 2025.

The rate of industrial robot adoption in some ASEAN Member States (e.g. Singapore, Thailand and Viet Nam) is increasing. The pace of adoption of industrial robots in ASEAN differs markedly, with Singapore leading, followed by Malaysia and Thailand. Most deployment of industrial robots takes place in the automotive, electronics, and metal and machinery industries.

During 2016–2019, industries in Singapore, Viet Nam and Thailand installed the largest numbers of industrial robots in the region. The annual pace of robot installation in Indonesia and Viet Nam is rising despite the low-cost labour environment in these countries. The impact of the pandemic on production could encourage more manufacturers in the region to automate operation.

In spending on the internet of things (IoT), Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam are major markets in the region. This stems from their strong focus on smart cities development, manufacturing and the rapidly growing digital economy. Many MNEs have established centres of excellence and R&D facilities to develop and customize technology solutions (IIoT) for local and MNE clients. The adoption of Industry 4.0 technologies and the establishment of smart factories by MNEs (a list that is expanding) has produced a demonstration effect that encourages other foreign and local firms to transform to Industry 4.0 – pushing up demand for such technologies.

The top 50 global industrial automation MNEs and major global IIoT MNEs have a presence in the region. Most of these MNEs are headquartered in the United States, Europe and Japan. Many have established significant activities in multiple ASEAN Member States, involving various business functions, from sales and distribution to manufacturing, training and R&D. Some have subsidiaries providing advanced industrial digital technology solutions.

INDUSTRY 4.0 PLANS, ACTIONS AND POLICY OPTIONS

ASEAN Member States are actively promoting the adoption of Industry 4.0 technologies to improve manufacturing efficiency and productivity. Industry 4.0 transformation can further boost the region's manufacturing potential, upgrade industrial development, enhance ASEAN's attractiveness for international production and support upgrading in GVCs. Transformation to Industry 4.0 is expected to yield up to $0.6 trillion in additional gross domestic product (GDP) annually in ASEAN by 2025 through productivity gains.

Nascent stage in Industry 4.0

Industry 4.0 transformation in ASEAN is still nascent. The degrees of digital readiness are uneven. Assessment of Industry 4.0 readiness of some Member States indicates that most firms (mainly SMEs) are at the Industry 1.0–2.0 state of technology use (involving manual and basic mechanization processes). A growing number of firms (mostly large firms and MNEs) are in the Industry 3.0 stage and moving towards Industry 4.0. Larger local and foreign companies are more ready to deploy Industry 4.0 technologies to upgrade plants or build smart factories. Member States with more vibrant manufacturing industries (e.g. Indonesia, Malaysia, Singapore and Thailand) are witnessing growing interest by local and foreign firms in adopting Industry 4.0 technologies.

National and regional plans

Most Member States have or are adopting Industry 4.0 plans and action programmes, which include emphasis on attracting investment and supporting MNE activities in digitalization. ASEAN Member States have adopted specific measures to attract FDI in Industry 4.0. These measures include efforts to improve national digital infrastructure, offer investment incentives and provide institutional support. In some cases, they have established dedicated industrial facilities to develop Industry 4.0 clusters and facilitated linkages with public R&D centres, universities and innovation hubs. Some have attracted investment in large data centres, ultra-high-speed broadband and 5G networks to build an efficient environment for the deployment of Industry 4.0 technologies.

At the regional level, Member States actively cooperate on digitalization and Industry 4.0 transformation, which has led to the adoption of agreements and declarations on Industry 4.0, as well as on cybersecurity, e-commerce and a smart cities network. Together with national plans and measures, along with MNE activities, regional actions can help strengthen the Industry 4.0 ecosystem.

Industry 4.0 impact on FDI

Industry 4.0 transformation can unlock opportunities to attract new types of investment in relevant industries; however, it can also have an impact on traditional labour-intensive FDI as operations become autonomously driven, smart and digitalized, replacing labour.

There is a symbiotic relationship between Industry 4.0 and the FDI environment. Digital adoption can improve the efficiency of the investment and manufacturing environment, which can enhance the attractiveness of the region for FDI in general. An efficient manufacturing hub also attracts manufacturers that produce Industry 4.0 hardware (equipment, parts and components) and software solutions. Yet, FDI in Industry 4.0 (e.g. technology solutions development, centres of excellence and R&D activities) can also strengthen the region's digital ecosystem.

SMEs in ASEAN can play a key role in the Industry 4.0 transformation. They are an important part of the Industry 4.0 ecosystem (e.g. through developing supporting industry). Their relationships with MNEs can accelerate Industry 4.0 technology adoption. Examples of mechanisms in this two-way channel include vendor relationships between MNEs and SMEs for technology upgrading, MNEs with specific Industry 4.0 technology programmes that target the digital transformation of ASEAN SMEs, technology start-ups in ASEAN that scale up with regionalization, and ASEAN and foreign venture capitalists that support regionalization of technology start-ups.

Challenges

There are challenges in attracting FDI in Industry 4.0. They relate to the limited (but expanding) market opportunities for hardware and technology solution adoption. Many firms are still reluctant to deploy digital technologies for various reasons, which include cost considerations,

capital requirements, lack of digital knowledge and lack of information on support options. These challenges are more pertinent to SMEs than to larger firms or MNEs. Thus, supporting SMEs in the transformation is important for attracting FDI in Industry 4.0 as SMEs can strengthen the underlying drive for market-seeking investment.

Policy options and ways forward

Policies to attract FDI in Industry 4.0 can be considered at three levels (figure 5). At the **contextual level**, cyberlaws, cybersecurity, data residency, data protection and privacy are important factors determining the attractiveness of the investment environment in sectors relevant to Industry 4.0.

For investment policymakers, investment authorities and investment promotion agencies, it is important to consider a number of key questions to set **strategic investment policy direction**. These include questions such as what FDI to attract to build digital infrastructure enablers and in which Industry 4.0 equipment and solutions manufacturing sectors ASEAN and individual ASEAN members have a competitive advantage to become leaders. The investment chapter of Industry 4.0 action plans could address such strategic questions and investment promotion agencies provided with policy guidance for implementation.

Figure 5. A framework for policy options

Source: ASEAN Investment Report 2020–2021 research.

Specific policy options to overcome the bottlenecks that impede Industry 4.0 transformation should target strengthening the capacity of Member States to attract FDI in relevant industries and activities. Doing so would include implementing measures to strengthen the Industry 4.0 ecosystem and facilitate investment, incentivizing SMEs, balancing between

implementing necessary regulation and promoting innovation, developing skills and building capacity, supporting regional cooperation in measurement of progress on Industry 4.0 and promoting Industry 4.0 awareness to manufacturers at all levels. To make the region even more attractive for FDI in sectors relevant to Industry 4.0, ASEAN Member States could strengthen efforts to promote sustainable digital development through the use of green energy, because some Industry 4.0 technologies (e.g. data centres) consume large amounts of electricity.

Continuous efforts to promote the application of Industry 4.0 technologies to all segments of industries could be supported by strengthening institutions and regional programmes for the promotion of FDI in Industry 4.0. A possible mechanism could be regular joint meetings of the ASEAN Coordinating Committee on Investment and the ASEAN e-Commerce Committee with an ASEAN body for Industry 4.0 transformation, and between the ASEAN Investment Area Ministerial Council and the ASEAN Digital Ministers. A regional Industry 4.0 centre could be considered as a resource centre to promote Industry 4.0 investment and adoption. A regular public-private sector forum on Industry 4.0 technologies and on approaches to attract relevant FDI to build a conducive ecosystem could be useful for regional policy development. Table 2 provides a summary of specific policy recommendations.

The prospects for FDI in Industry 4.0 relevant industries and activities are positive. Lessons from the pandemic related to the disruption of supply chains, the effects of lockdown measures on production and the role of Industry 4.0 technologies in improving efficiency – combined with the strong public policy push – are expected to further accelerate digital adoption in the manufacturing industry in the post-pandemic recovery phase.

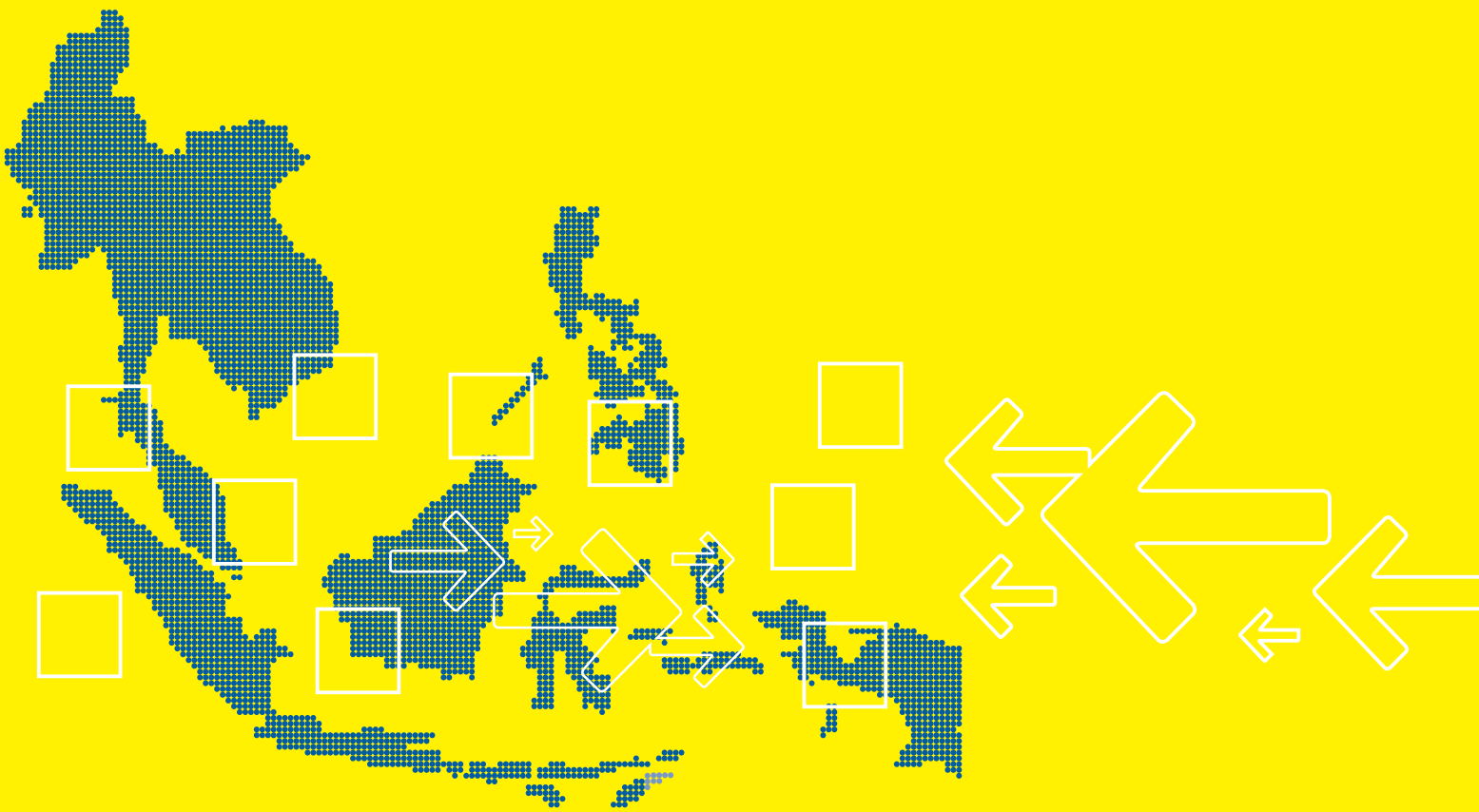
Table 2. Summary of key recommendations

Key areas	Specific measures
Strategic investment policy direction	• Determine strategic areas (infrastructure enablers and Industry 4.0 technology and solution segments) for FDI promotion, on the basis of existing industrial capacities and competitive advantages (e.g. electronics, automotive clusters) • Determine adjacent and complementary strategic sectors for FDI promotion – e.g. green energy development is a key locational determinant for investment in data centres
Industrial infrastructure and ecosystem	• Selectively invest in and upgrade industrial parks to support Industry 4.0 development, focusing on those that have strong clusters of industries with a high propensity to adopt relevant technologies and solutions (e.g. electronics, semiconductors, machinery) • Promote Industry 4.0 cluster development involving SME participation and supplier linkages with MNEs in designated parks, including through MNE-led knowledge development and training programmes
Regional programmes	
Coordination	• Consider regular joint meetings of investment and digital bodies to set policy direction for investment in Industry 4.0 activities
Promotion	• Consider the establishment of an Industry 4.0 resource centre and/or forums for SMEs to support knowledge development, training and sharing of experience
Informed policymaking	• Improve the measurement of progress in Industry 4.0 development, identifying data requirements for policy development and establishing comparable indicators • Promote further research on investment opportunities in Industry 4.0

Source: ASEAN Investment Report 2020–2021 research.

PART ONE

FDI AND MNE DEVELOPMENT IN ASEAN



CHAPTER 1

FDI and Corporate Investment Trends

1.1. INTRODUCTION

The past two years (2019 and 2020) were exceptional for ASEAN; 2019 saw the highest ever inflows of foreign direct investment (FDI), at $182 billion – making the region the largest recipient of FDI in the developing world – and 2020 was marked by the unprecedented impact of the COVID-19 pandemic, which led to a 25 per cent fall in FDI to the region, to $137 billion.

The year 2020 also saw a few major developments that will shape the region's investment environment and business ecosystem beyond 2021: (i) the signing of the Regional Comprehensive Economic Partnership (RCEP) Agreement (chapter 2), (ii) continued diversification of FDI by multinational enterprises (MNEs) to ASEAN, (iii) adoption of pandemic response measures and the ASEAN Comprehensive Recovery Framework, which is favourable to FDI, (iv) accelerated implementation of national infrastructure plans and development of digital infrastructure, which opens up more opportunities to MNEs and (v) the growth of Chinese FDI and non-equity forms of investment in the region.

This chapter examines FDI trends and MNE developments in ASEAN between 2019 and 2020, as well as emerging investment issues mentioned above (pandemic response measures are covered in chapter 2). It highlights cross-border mergers and acquisitions, international project finance and greenfield realized investment activities of MNEs from within and outside the region. Given its significance as the largest source of FDI and because it is at the heart of ASEAN regional economic integration, specific analysis on the development of intra-ASEAN investment is covered. Investment trends in international project finance, mostly concentrated in infrastructure related activities and through non-equity arrangements, are also analysed. The chapter concludes with an outlook on FDI prospects in ASEAN.

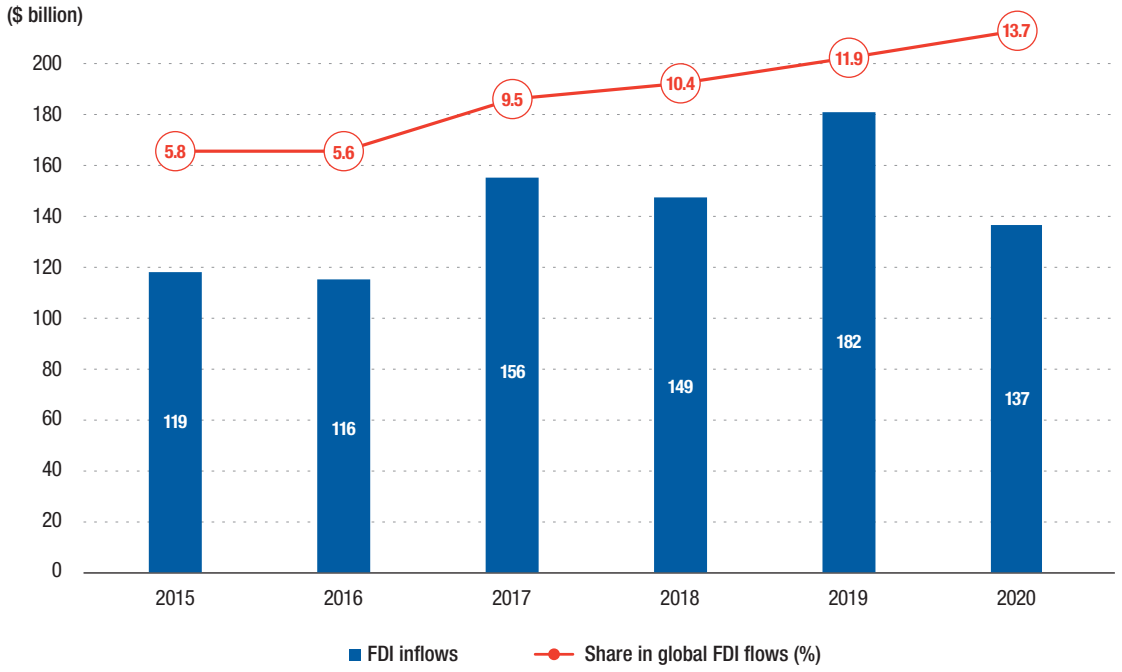
1.2. FDI TRENDS AND DEVELOPMENTS IN ASEAN

Following the all-time high inflows in 2019, FDI in ASEAN – an engine of global FDI growth for the past decade – contracted by $45 billion (-25 per cent) in 2020 because of the impact of the pandemic (figure 1.1). Lockdown measures, supply chain disruptions, falling corporate earnings, successive waves of the pandemic, economic uncertainty and postponement of investment by MNEs led to the decline. Other international investment activities in the region also shrunk.

Announced greenfield investment declined by 17 per cent to $68 billion, international project finance activities fell by 21 per cent to $53 billion and cross-border mergers and acquisition (M&A) sales fell to -$4.7 billion from $9.8 billion in 2019 *(WIR 2021).*

Despite the decline, the region's share of global FDI rose from 11.9 per cent in 2019 to 13.7 per cent, suggesting that it remained an attractive investment destination. FDI inflows remained more than twice the level seen during the 2007–2008 global financial crisis and nearly five times more than the annual average during 2002–2004 outbreak of severe acute respiratory syndrome (SARS).

Figure 1.1. FDI inflows in ASEAN and share in world total, 2015–2020 (Billions of dollars and per cent)

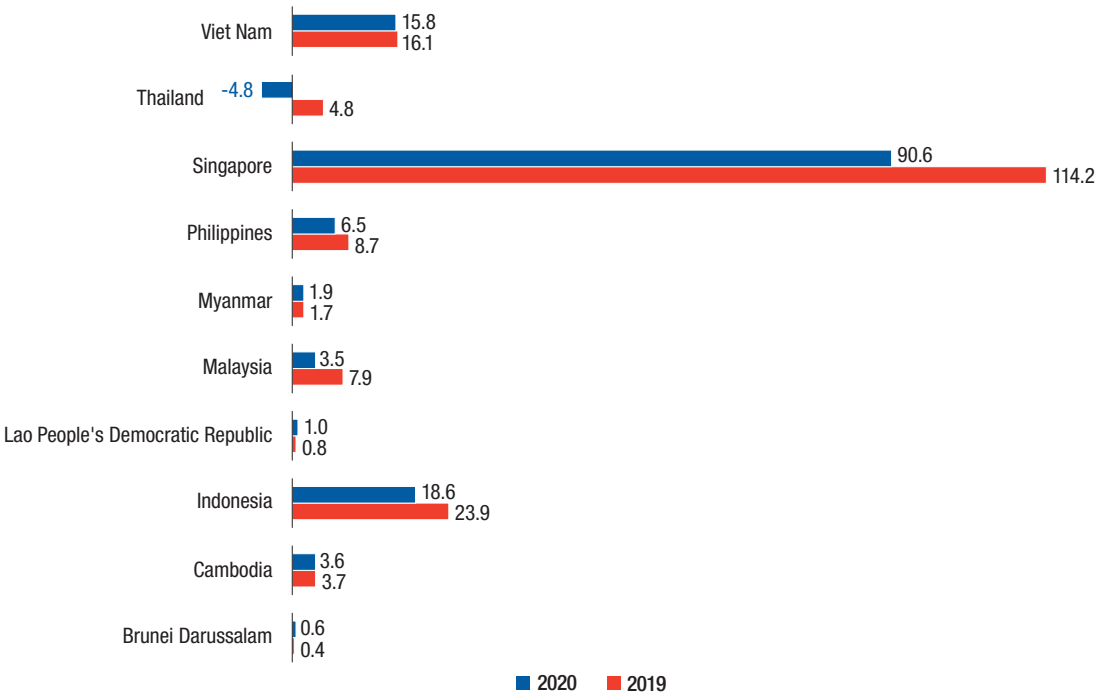


Source: UNCTAD and ASEAN Secretariat.

The pandemic affected most ASEAN Member States, with seven seeing a drop in investment – some more significant than others (figure 1.2). Three Member States bucked the trend (Brunei Darussalam, the Lao People's Democratic Republic and Myanmar), seeing a rise in FDI but from a low base. Overall, Brunei Darussalam and the CLMV countries (Cambodia, the Lao People's Democratic Republic, Myanmar and Viet Nam) were relatively resilient, with either an increase in investment or a small change in inflows.

The three largest recipients (Singapore, Indonesia and Viet Nam, in that order), which accounted for more than 90 per cent of inflows in 2020, all recorded FDI declines. They account for most of the fall in FDI in ASEAN last year.

Figure 1.2. FDI flows in ASEAN Member States, 2019 and 2020 (Billions of dollars)



Source: ASEAN Secretariat, ASEAN FDI database.

Top 10 investors

FDI flows in ASEAN were more concentrated in 2020. The top 10 investors accounted for 75 per cent of FDI in the region as compared with 71 per cent in 2019 (table 1.1). Investment from most of these top 10 fell. FDI from Japan, a traditional major source of investment, plummeted by 65 per cent to just $8.5 billion. MNEs from the European Union (EU) invested 40 per cent less, with a combined amount of $10 billion. FDI from the United Kingdom plunged to -$13 billion because of Tesco's divestment of its supermarket operations in Malaysia and Thailand. Exceptions were the United States, Thailand and Switzerland, from which FDI rose.

Table 1.1. Top 10 investors in ASEAN, 2019 and 2020
(Billions of dollars and per cent)

Economy	2019	Economy	2020
United States	34.6	United States	34.7
Japan	23.9	Singapore	14.0
Singapore	15.7	Hong Kong, China	12.0
Hong Kong, China	12.9	Japan	8.5
Canada	10.1	China	7.6
China	9.0	Korea, Republic of	6.8
United Kingdom	7.9	Thailand	5.5
Korea, Republic of	7.5	Canada	5.2
Switzerland	4.2	Switzerland	4.6
Thailand	3.8	Netherlands	4.6
Top 10	**129.5**	**Top 10**	**103.6**
Share of top 10 (%)	**71.2**	**Share of top 10 (%)**	**75.4**

Source: ASEAN Secretariat, ASEAN FDI database.

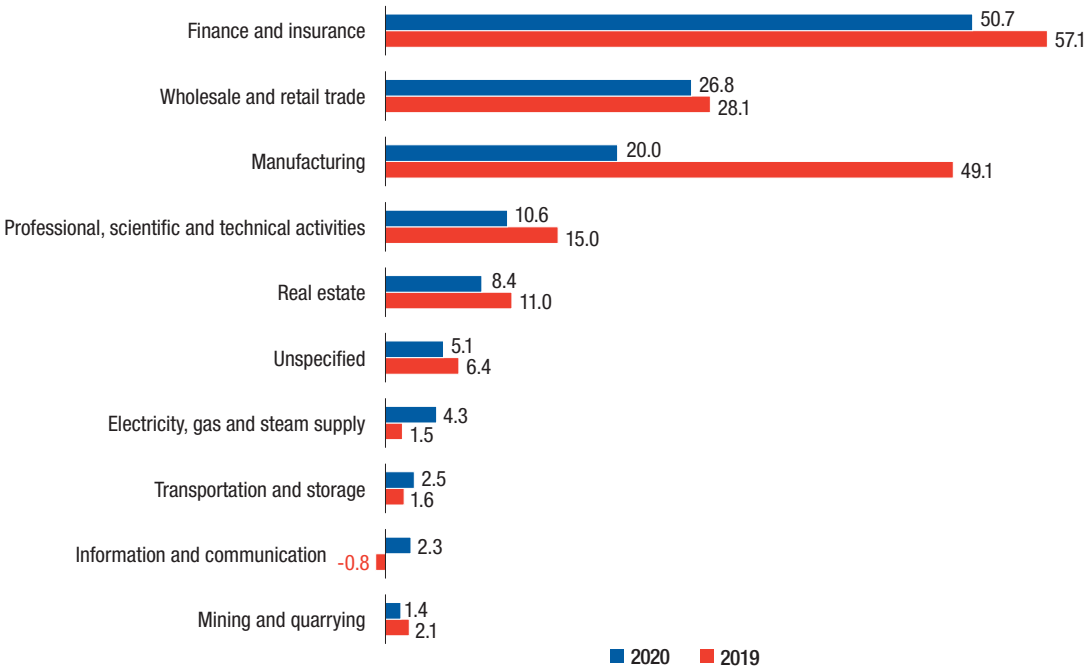
Top 10 industries

The top 10 industry recipients accounted for 95 per cent of FDI in 2019 and 2020, with the traditional top 3 (finance, wholesale and retail, and manufacturing) accounting for more than 70 per cent.

The pandemic affected industries differently. All industries other than those in infrastructure-related sectors saw FDI fall (figure 1.3). FDI in manufacturing contracted by 59 per cent, from $49 billion in 2019 to $20 billion – a key contributor to the overall decline. Supply chain disruption, scaling down of operations and a slump in international demand (as in the garment industry) were major factors. FDI also faltered in services industries such as finance, hospitality, tourism, real estate and construction.

However, investment in infrastructure-related industries such as electricity, and in information and communication, as well as transportation and storage rose – underscoring the resilience of these industries in an economically challenging time. FDI in wholesale and retail trade declined marginally, by 4.6 per cent, to $26.8 billion – a level that is still high, sustained by continued growth in digital technologies, e-commerce and online activities. Strong investment in the digital economy, the roll-out of 5G licenses and active investment in data centres and cloud computing, including relocation of factories to some Member States, helped cushion the fall to some extent.

Figure 1.3. Top 10 industry FDI recipients, 2019 and 2020 (Billions of dollars)



Source: ASEAN Secretariat, ASEAN FDI database.

FDI in individual Member States

FDI declined in six Member States. The drop was largest in five developed-country Member States (Thailand, Malaysia, the Philippines, Indonesia, Singapore), and Viet Nam, in that order. But there were bright spots despite the pandemic. Three Member States saw a rise in FDI (Brunei Darussalam, the Lao People's Democratic Republic and Myanmar) but from a low level, and inflows in one (Cambodia) were flat.

Brunei Darussalam

FDI in Brunei Darussalam rose 54 per cent, from $375 million in 2019 to $577 million in 2020. A key contributor was the strong investment in oil and gas by investors from China and ASEAN. Zhejiang Hengyi Group (China) and a local partner (Damai Holdings) expanded the operation of an oil and refinery project in an industrial park.[1] The construction of the second phase of the $13.6 billion facility is expected to take three years.

Indonesia

FDI in Indonesia declined by 22 per cent, to $19 billion, because of a 58 per cent drop in investment in the manufacturing industry. In contrast, investment in financial services, logistics and communication, and real estate rose, but not enough to help pull up inflows. FDI from two major sources (Japan and Singapore) fell significantly. Inflows from Japan fell by 75 per cent, to just $2.1 billion, and inflows from Singapore fell by nearly 30 per cent, to $4.6 billion. Despite the decline in flows from Singapore, intra-ASEAN investment was the largest source of investment, increasing by 19 per cent to $8.2 billion because of a rise in investment from Thailand, which rose 180 per cent to $3.2 billion. The share of intra-ASEAN investment rose from 29 per cent of all FDI to the country in 2019 to 44 per cent in 2020.

Malaysia

FDI in Malaysia fell by 55 per cent, from $7.9 billion in 2019 to $3.5 billion in 2020 – the lowest level in the decade. FDI in the country was significantly affected by the pandemic in Q2 2020, when inflows declined by 66 per cent compared to the previous quarter, and Q3 recorded the lowest level of investment ($182 million) for the year.[2] Inflows started to climb in Q4 to about the level of Q1 ($1.4 billion), suggesting prospects for higher inflows in 2021. ASEAN was the largest source of investment, which rose to $2.5 billion, an increase of 78 per cent. Intraregional investment accounted for more than 70 per cent of investment in 2020 because of robust investment from Singapore and Thailand. Investment from other major sources such as Japan, the United Kingdom and the United States remained low. The construction industry suffered a major setback with falling investment, mainly linked with repayment of intracompany loans (a key component of FDI). The manufacturing industry, a major recipient, was also affected adversely and attracted only about $1 billion in FDI. Despite being down, FDI in the services industry fell less at $1.7 billion, accounting for 50 per cent of 2020 inflows.

Philippines

FDI in the Philippines declined by 25 per cent, to $6.5 billion. Key factors hampering investment were the impact of the pandemic and economic challenges. All components of FDI (equity, intracompany loans and reinvested earnings) were down. Injections of equity investment, while low, occurred mainly in manufacturing, real estate and finance.[3] Japan, the Netherlands, Singapore and the United States were main investors. However, FDI in the first four months of 2021 rose by 56 per cent to $3.1 billion as compared with the same period in 2020, suggesting a promising prospect for higher inflows in 2021. The rise in intracompany loans was a key reason.

Singapore

FDI in Singapore contracted by 21 per cent to $91 billion, Although the country remained the region's largest recipient and largest source of investment. FDI contracted in the three largest recipient industries (finance, wholesale and retail trade, and manufacturing), but investment in manufacturing declined the most – more than 80 per cent – to $3.3 billion. FDI in other major industries, except information and communication, also fell. Investment from major sources (except Hong Kong (China) and the United States) declined considerably. Investment from Japan and the United Kingdom contracted significantly, with FDI from Japan falling by 72 per cent to about $2.2 billion and FDI from the United Kingdom falling from $6.9 billion in 2019 to -$2.9 billion. Inflows from the European Union dropped by $838 million to $9.6 billion.

Thailand

FDI in Thailand sank to -$4.8 billion, driven by the divestment of Tesco (United Kingdom) to a Thai investor group led by Charoen Pokphand for $10 billion. Investment from ASEAN, a major investment source, plunged by more than half, from $5.2 billion in 2019 to $2.2 billion, because of a 60 per cent drop in investment from Singapore. Inflows from other major investors (China, Hong Kong (China), Japan and the United States) all fell. FDI in manufacturing and finance plummeted, with manufacturing recording a sixfold decline to $822 million and finance registering a continued decline from -$1.4 billion in 2019 to -$6.4 billion in 2020.

CLMV countries

FDI trends in the CLMV countries are covered in section 1.3.

1.2.1. Cross-border M&As

Cross-border M&As in the region recorded a precipitous dive, from $9.8 billion in 2019 to -$4.7 billion in 2020. The lack of megadeals also suppressed M&A volumes in 2020, as the number of deals exceeding $250 million declined from 34 in 2019 to 18 in 2020.

All Member States, except Indonesia, saw a fall in cross-border M&A values. M&A sales in Singapore fell by 59 per cent, from $4.7 billion to just $2.0 billion, while those in Thailand dropped from -$0.3 billion in 2019 to -$9.8 billion in 2020 because of a mega divestment deal in the wholesale and retail business (that of Tesco).

Local firms further consolidated their market positions by acquiring foreign-owned assets. Thai companies were particularly active in 2020, contributing to strong intraregional M&A activities. Of the 10 largest deals in ASEAN, 5 were by Thai companies, amounting to $15 billion. In the largest, an investor group acquired the operations of Tesco (United Kingdom) in Thailand for $10 billion and its operations in Malaysia for $700 million (table 1.2). Bangkok Bank acquired Bank Permata (Indonesia) for $2.3 billion, and Thai Beverage acquired two major assets in Singapore, Frazer Commercial Trust for $1.2 billion and Asia Retail Fund for $776 million.

Table 1.2. Major M&A deals in ASEAN, by value, 2020

Ultimate acquiring company	Ultimate acquiring economy	Target company	Target country	Target industry	Value ($ millions)	Shares owned after (%)
Investor Group	Thailand	Tesco Stores (Thailand)	Thailand	Grocery stores	9 900.1	100
Bangkok Bank	Thailand	PT Bank Permata	Indonesia	Banks	2 282.2	89.1
Investor Group	Singapore	Aviva	Singapore	Insurance agents, brokers, and service	1 489.3	51
Kimberly-Clark	United States	PT Softex Indonesia	Indonesia	Sanitary paper products	1 200.0	100
Thai Beverage	Thailand	Frasers Commercial Trust	Singapore	Real estate investment trusts	1 124.2	100
Netfin Acquisition	United States	Triterras Fintech	Singapore	Functions related to depository banking, nec	995.0	100
Thai Beverage	Thailand	AsiaRetail Fund	Singapore	Management investment offices, open-end	776.1	100
Investor Group	Thailand	Tesco Stores (Malaysia)	Malaysia	Grocery stores	700.0	100
KB Financial Group	Korea, Republic of	Prasac Microfinance Institution	Cambodia	Miscellaneous business credit	605.3	70
China Maple Leaf Education System	China	Star Readers	Singapore	Elementary and secondary schools	515.4	100
FWD Group	Hong Kong, China	Commonwealth Life	Indonesia	Life insurance	426.0	80
PX Holdings	Hong Kong, China	Compart Systems	Singapore	Valves and pipe fittings	398.0	100
China Datang	China	PT DSSP Power Mas Utama	Indonesia	Business consulting services, nec	394.0	75
Royal Dutch Shell	Netherlands	Total E&P Deep Offshore Borneo	Brunei Darussalam	Cyclic crudes and organic dyes	300.0	100
PT Indonesia Asahan Aluminium	Indonesia	PT Vale Indonesia	Indonesia	Ferro-alloy ores, except vanadium	294.2	20
CDL Hospitality REIT	Singapore	W Hotel Worldwide	Singapore	Hotels and motels	276.0	100
Zhuhai Port	China	Xinghua Port Holdings	Singapore	Water transportation services, nec	263.7	97.1
Meiji Holdings	Japan	Austasia Investment Holdings	Singapore	Dairy farms	254.4	25

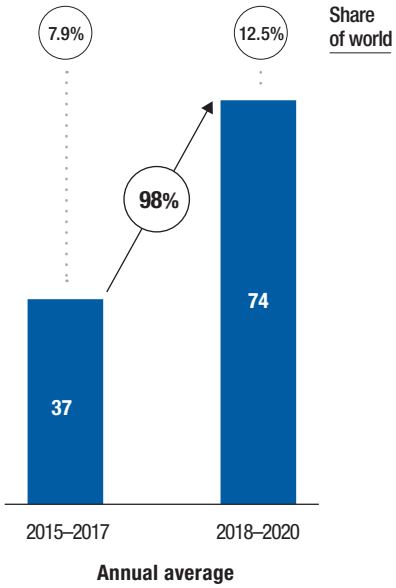
Source: UNCTAD M&A database.
Note: nec = not elsewhere classified.

1.2.2. International project finance

The value of international project finance in ASEAN fell, from $67 billion in 2019 to $53 billion in 2020. However, the longer-term trend, comparing 2015–2017 and 2018–2020, is encouraging. International project finance[4] values in ASEAN nearly doubled between the two periods, from an annual average of $37 billion in 2015–2017 to $74 billion in 2018–2020.

ASEAN is an important destination for international project finance activities, which mostly include infrastructure projects and activities relating to sustainable development goals (e.g. renewable energy). The region's share of international project finance values worldwide rose from 7.9 per cent in 2015–2017 to 12.5 per cent in 2018–2020 (figure 1.4). Asia, the largest destination for international project finance, accounted for nearly 40 per cent of global values in 2018–2020, and ASEAN accounted for 32 per cent of Asia's share. This underscores the importance of ASEAN within Asia for such deals.

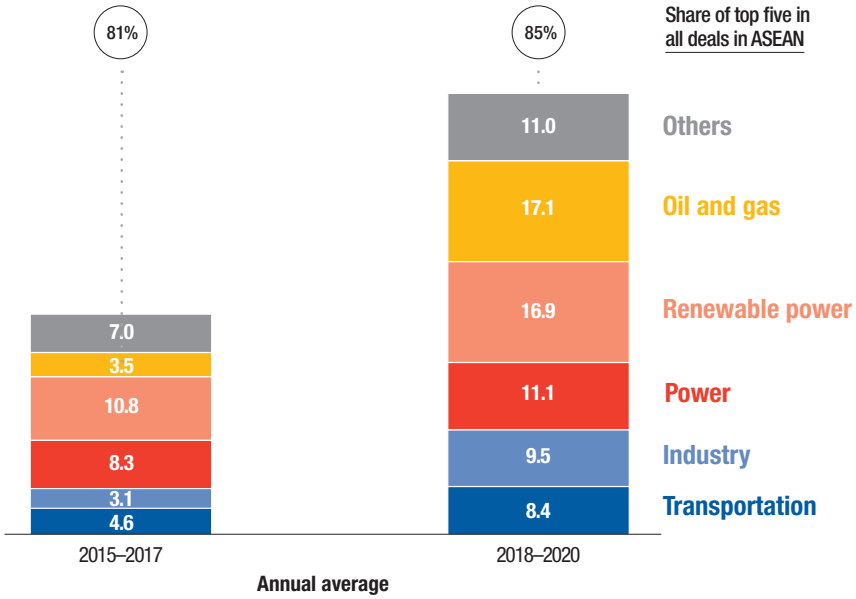
Figure 1.4. International project finance values in ASEAN and share of world, annual averages 2015–2017 and 2018–2020 (Billions of dollars and per cent)



Source: UNCTAD, Project finance database.

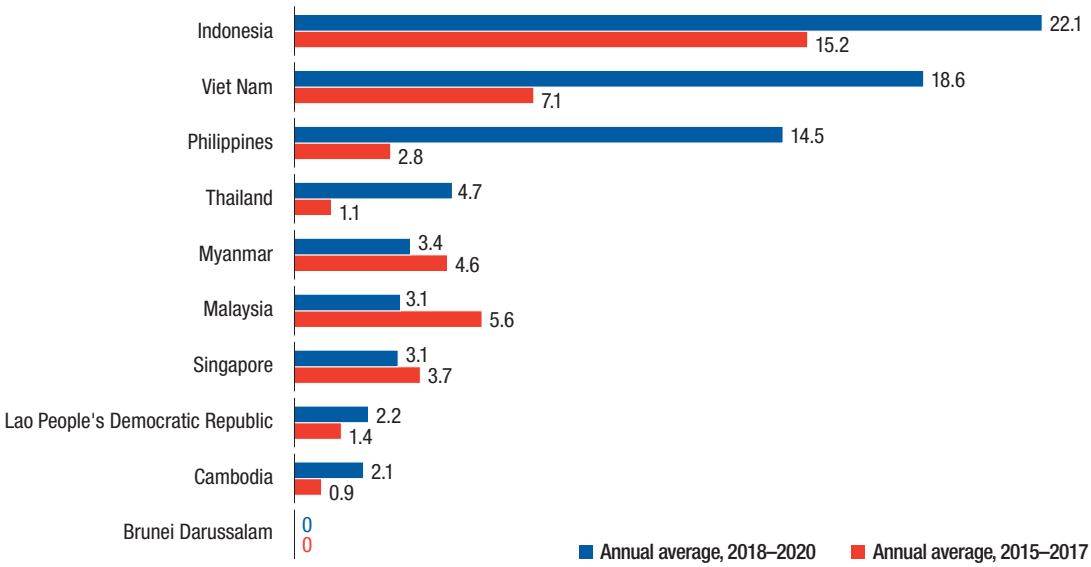
Most of the projects are in infrastructure-related sectors (e.g. power, renewable energy and transportation) and in oil and gas, reflecting increasing opportunities for investment in infrastructure and extractive industries and the dynamism of the region (figure 1.5). Three Member States (Indonesia, Viet Nam and the Philippines) stood out in international project finance in 2018–2020 because of the active push for infrastructure development and investment opportunities in these industries (figure 1.6).

Figure 1.5. ASEAN: Top five industries in international project finance, by values, annual averages 2015–2017 and 2018–2020 (Billions of dollars and per cent)



Source: UNCTAD, Project finance database.

Figure 1.6. International project finance values in ASEAN, by host country, annual averages 2015–2017 and 2018–2020 (Billions of dollars)



Source: UNCTAD, Project finance database.

1.2.3. MNE activities and operations in ASEAN

MNE FDI activities in some key industries, such as manufacturing, real estate and construction, were significantly impacted by the pandemic, which curbed investment and expansion plans. Nevertheless, some MNEs continued to invest and expand factories, mostly through greenfield investment. Online activities and the digital economy saw active participation by MNEs, including in digital infrastructure (5G networks, data centres and cloud facilities) (chapter 3). Infrastructure-related industries such as power generation and transportation were resilient, and MNEs continued to establish R&D facilities and regional headquarters, concentrated in a few Member States.

This section highlights realized investment projects, mostly greenfield investment activities, that started operation or commenced construction in 2019–2020. Announced greenfield investment in ASEAN declined by 17 per cent to $68 billion but new factories and businesses were established across different industries (e.g. automotive and digital economy) during the period.

(a) Agriculture

FDI in agriculture, forestry and fishery fell by 85 per cent to $370 million. Nonetheless, some MNEs continued to expand operations in agriculture activities in the region. For instance, in 2019 Posco (Republic of Korea) inaugurated a second rice processing plant in Myanmar and Pepsico (United States) expanded its potato-cultivating project to other Vietnamese provinces. In 2020, De Heus (Netherlands) constructed an aqua-feed production facility in Myanmar and Archer Daniels Midland (United States) started operating a livestock feed plant in Viet Nam.

(b) Energy and mining

In 2019, Neste (Finland) completed development of a $1.6 billion expansion project at its diesel renewable plant in Singapore and Linde (United Kingdom) started construction of a $1.4 billion integrated gas manufacturing complex in the same host country. Hengyi Petrochemical (China) commenced operations of an oil refinery and petrochemical facility in Brunei Darussalam, Xin Ye Precious Metal Technology (Taiwan Province of China) opened a $1 million gold processing facility in the Philippines and Cabot Corporation (United States) started construction of a carbon black plant in Indonesia.

In 2020, SK Lubricant (Republic of Korea) acquired a 49 per cent stake in Mekong Petrochemical in Viet Nam for $42 million. ExxonMobil (United States) started construction of a multibillion-dollar expansion project at its refining facility in Singapore. Royal Dutch Shell (Netherlands) started production of a gas production facility in Malaysia and opened an oil import terminal in the Philippines. Yunnan Dongyan Industrial (China) and a local partner started the first phase of a $2 billion petroleum refinery complex in the Lao People's Democratic Republic. Hengyi Petrochemical (China) expanded its operations with the development of the second phase of a petrochemical complex with a local partner in Brunei Darussalam.

(c) Manufacturing

After a record level of FDI in manufacturing in 2018 and a second highest level in 2019, MNE activities in manufacturing suffered a major setback in 2020 because of the difficult

operating conditions (e.g. lockdown and uncertainties), supply chain disruptions, and scaling down of activities or postponement of investment implementation. However, some industries bucked the trend. In the automotive, electronics, chemicals and health care products (e.g. personal protection equipment and sanitizer) industries, some MNEs expanded operations in the region. In the automotive industry, new segments – parts and components (batteries for electric cars) and production of electric cars – continued to receive attention from major MNEs. Some opened more facilities for battery production, which further strengthened the industries supporting production of electric vehicles.

Food and beverages

In the food and beverages segment, European MNEs remained active in the region in 2019–2020. In 2019, Nestlé (Switzerland) started expansion of production capacity in three factories in Indonesia with a $100 million investment. Olam (Singapore) acquired from YTS Holdings (Singapore) an 85 per cent stake in BT Cocoa in Indonesia for $90 million. In 2020, Intersnack (Germany) set up a cashew processing plant in Viet Nam; Tate & Lyle (United Kingdom) continued the process to acquire an 85 per cent stake in a manufacturer of tapioca and modified food starch in Thailand; Givaudan and Bühler (both Swiss) started construction of an innovation centre dedicated to plant-based food in Singapore; and Synergy Flavors (Ireland) opened a blending facility in Thailand. In the same year, Nisshin Seifun Group (Japan) opened its first premixed flour plant in Viet Nam.

Some European MNEs that already have a significant presence in the region continued to expand with new facilities. Nestlé (Switzerland), after having established the world's largest Milo manufacturing plant in Malaysia in 2019 for $22 million, opened a coffee farm centre in Viet Nam in 2020 and expanding production capacities for manufacturing of ice cream products and UHT (ultra-high-temperature) beverages in Thailand. Barry Callebaut (Switzerland) added a fourth chocolate line to its factory in Singapore. Other MNEs also expanded operations in 2020: Nagase (Japan) opened a regional innovation centre for food materials in Singapore, and Showa Aluminum Can, a subsidiary of Showa Denko (Japan), built a third manufacturing plant for beverage containers in Viet Nam for $67 million.

Automotive

Some automotive MNEs that are original equipment manufacturers (OEMs) built factories, opened marketing and distribution facilities, or established battery plants (table 1.3). In 2019, Toyota (Japan) started construction of a $57 million manufacturing plant in Myanmar and in 2020; Ford (United States) began an $82 million upgrade and expansion of facilities in Viet Nam, Great Wall Motor (China) started construction of a production facility in Thailand to start operation in 2021, and Hyundai Motor (Republic of Korea) is expanding production capacity in Indonesia and building new plant in Viet Nam. The promotion of electric vehicle (EV) production in some Member States are attracting traditional OEM and new type of automotive manufacturers. For instance, major automotive manufacturers such as from Japan (Mitsubishi Motors, Mazda, Nissan) and Europe (Audi, BMW, Mercedes-Benz) are expanding production facilities for EV production in Indonesia and Thailand. Foxconn (Taiwan Province of China) is partnering with PTT (Thailand) to produce EVs in Thailand and Tesla (United States) is planning to operate in Indonesia.

Some automotive OEM-MNEs also expanded their operations into other business functions in 2019–2020. Isuzu Motors and Honda Motors (both Japan) opened sales, service and spare parts centres in Malaysia. Maserati (Italy) established a showroom in Cambodia together with a local partner (HGB Group). Zhejiang Geely Holding Group (China) opened two showrooms in the Philippines through a local distributor, Sojitz G Auto Philippines.

Some parts and components manufacturers further expanded with facilities. In 2019, Denso (Japan) started construction of a second manufacturing facility in Cambodia, and Continental (Germany) with a $30 million motorcycle tyre factory in Thailand. In 2020, Xingda (China) established its first overseas steel cord products facility in Thailand, to serve tyre manufacturers, and Sagami (Japan), a coil maker, started construction of a $5 million automotive part factory in Indonesia.

MNEs in the automotive industry in ASEAN are giving more attention to battery production for electric vehicles. In 2019 BMW, in partnership with Dräxlmaier Group (both German), opened a $20 million high-voltage battery production plant in Thailand, and Toyota (Japan) opened a battery recycling plant. Mercedes-Benz (Germany), working with local partners, invested over $114 million in a battery factory in Bangkok. Chinese, Japanese and Korean investors began construction of a $4 billion EV battery project in 2019 in Indonesia. In 2020, a few large-scale investments in battery plants were announced by Asian MNEs. For instance, Contemporary Amperex Technology (China) announced plans to invest in a $5 billion lithium battery plant in Indonesia and LG (Republic of Korea) consortium announced a $9.8 billion battery investment in the same host country. The consortium comprises LG Chem, LG Energy Solution, LG International, steelmaker POSCO (all Republic of Korea) and cobalt company Huayou Holdings (China). If realized, these significant investment projects can make an impact on future levels of FDI in the automotive industry. FDI in production of batteries for EVs have led to a rise in investment interests by MNEs in upstream activities. Many Chinese companies have invested in upstream activities and in the production of EV batteries in Indonesia. GEM, a Chinese EV battery material supplier, is constructing a $700 million nickel processing plant in Indonesia, and Tsingshan Holding (China), a steel manufacturer has invested more than $5 billion in the same host country in 2020.

Table 1.3. Automotive assemblers and OEMs with new or expanded plants in ASEAN, 2019 and 2020 (Selected cases)

Company	Headquarters	Host country	Investment activity	Year
Bayerische Motoren Werke (BMW)	Germany	Thailand	Launched local assembly of high-voltage batteries	2019
Bridgestone	Japan	Thailand	Opened a tyre factory	2019
Cooper Tire & Rubber	United States	Viet Nam	Opened a truck and bus tyres manufacturing plant	2019
Daimler	Germany	Thailand	Inaugurated a factory for plug-in hybrid batteries	2019
ESMO Group	Korea, Republic of	Viet Nam	Inaugurated an automotive components production factory	2019

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Table 1.3. Automotive assemblers and OEMs with new or expanded plants in ASEAN, 2019 and 2020 (Selected cases) (Concluded)

Company	Headquarters	Host country	Investment activity	Year
GS Yuasa	Japan	Myanmar	Started operation of a battery plant	2019
Gui Zhou Tyre	China	Viet Nam	Broke ground on a plant for production of truck and bus tyres	2019
Hyundai Motor	Japan	Viet Nam	Broke ground on a manufacturing facility	2020
Maxam Tires	United States	Viet Nam	Opened a specialty off-the-road tyre facility	2020
Mitsubishi Motors	Japan	Malaysia	Migrated to a larger parts warehouse	2020
Schaeffler Group	Germany	Viet Nam	Opened a production plant	2019
Sumitomo Rubber Industries	Japan	Singapore	Established a wholly owned subsidiary	2020
Toyota	Japan	Thailand	Opened a battery life-cycle management plant	2019
Volvo	Sweden	Thailand	Opened a multi-purpose warehouse	2020
ZF Friedrichshafen	Germany	Viet Nam	Opened first chassis modules plant	2019

Sources: Company websites and media.

Electronics

As in past years, many electronic MNEs also continued to expand operations in the region. In 2019, Panasonic (Japan) started construction of a $45 million second factory in Viet Nam, Sumitomo Corporation (Japan) opened an electronic components factory in Cambodia and Ever Win International (United States) opened a manufacturing facility in the Philippines. In 2020, some electronic MNEs built new facilities or expanded in the region. In Malaysia, Murata (Japan) constructed an electronic component factory, Lam Research (United States) started construction of a wafer production facility, Dialight opened an LED manufacturing facility and TT Electronics (both British) inaugurated a manufacturing facility. Meiloon Industrial (Taiwan Province of China) broke ground on a production facility in Indonesia, while Sumitronics (Japan) opened production facilities in Cambodia and Malaysia. Sanmina (United States) expanded facilities in Thailand, Foxconn (Taiwan Province of China) opened a display manufacturing factory in Viet Nam and 2CRSi (France) established a subsidiary in Singapore. USI (Taiwan Province of China) started construction of a $200 million phase-one facility for production of chips for wearable electronic devices in Viet Nam.

Chemicals

In 2019, a subsidiary of Nippon Shokubai (Japan) started construction of a $200 million acrylic acid plant in Indonesia. Holland Colours (Netherlands) expanded a manufacturing facility in Indonesia to increase production of light-blocking colorants in polyethylene terephthalate (PET) packaging for dairy applications. In Thailand, Lenzig (Austria) laid the foundation stone to build one of the world's largest lyocell fiber plants, estimated at $457 million and Total Corbion (Netherlands) established a $150 million bioplastic plant facility.

In 2020, Gunze (Japan) opened a $12 million shrink-film plant in Viet Nam. Sinochem (China) started construction of a $331 million polymer additives facility and launched a production line for polycarbonate films in Thailand, where Covestro (Germany) broke ground on a high-performance elastomers manufacturing facility. Suez (France) announced the opening of the group's first plastic recycling plant in Asia, in Thailand.

Pharmaceuticals

In 2019, Novo Nordisk Pharmatech (Denmark) opened its first overseas representative office in Singapore. In 2020, Novartis (Switzerland) invested more than $6 million in a legal entity capable of importing the group's pharmaceutical products in Viet Nam. Otsuka Pharmaceutical (Japan) and Clinigen (United Kingdom) both opened local subsidiaries in Malaysia to handle sales of pharmaceutical products there. Two other Japanese companies, Daiichi Sankyo and Eisai, launched wholly owned subsidiaries in Viet Nam to support activities for the sale and promotion of pharmaceutical products. Rayont (United States) acquired a Malaysian life sciences company that owns the exclusive license to register and market a cancer-fighting technology across sub-Saharan Africa. NephroPlus (India) secured its first overseas acquisition by taking a majority stake in Royal Care Dialysis (Philippines), which owns six dialysis centres.

(d) Services

Wholesale and retail

The wholesale and retail industry is a major recipient of FDI in ASEAN and was relatively resilient to the impact of the pandemic. FDI in the industry suffered only a small drop in investment in 2020 (5 per cent to $26.8 billion) because of continuing MNE activities in retail businesses and supermarkets. Some MNEs expanded their operations in ASEAN through M&As (e.g. Thai Charoen Pokphand group).

In 2019 and 2020, wholesale and retail MNEs – especially in the food and beverages and clothing industries – continued to expand their presence in ASEAN by establishing production facilities, retail outlets and representative offices (table 1.4). In 2020, Lulu Hypermarket (United Arab Emirates) and Aeon (Japan) opened supermarkets in Indonesia and in Viet Nam, respectively. Some restaurant chains inaugurated their first outlets in targeted ASEAN Member States. They include Taco Bell (United States) in Indonesia and Tim Hortons (Canada) in Thailand. Apple (United States) opened a store in Singapore in 2020 and Nike (United States) inaugurated a flagship store in Bangkok.

Table 1.4. Wholesale and retail MNEs with new investments in ASEAN, 2019 and 2020 (Selected cases)

Company	Headquarters	Host country	Investment activity	Year
American & Efird Global	United States	Viet Nam	Opened a thread manufacturing facility	2019
Ethan Allen Interiors	United States	Cambodia	Opened a design centre	2019
Hennes & Mauritz (H&M)	Sweden	Viet Nam	Opened a store in Danang City	2019
Ikea Group	Sweden	Malaysia, Philippines	Opened stores	2019
Lacto	Japan	Philippines	Established a subsidiary to purchase and sell milk ingredients and cheese	2019
Segafredo Zanetti	Italy	Indonesia	Opened a coffee outlet	2019
Sozio	France	Indonesia	Inaugurated a factory	2019
Enoteca	Japan	Thailand	Opened a fully owned sales unit	2020
Foot Locker	United States	Singapore	Inaugurated an outlet	2020
Hanesbrands	United States	Philippines	Opened several stores for one of its brands	2020
Hang Heung	Hong Kong, China	Singapore	Opened its first overseas outlet	2020
Jimmy Choo	United Kingdom	Thailand	Opened its third store in Thailand	2020
Lego Group	Denmark	Malaysia	Opened its first Lego-certified store in Malaysia	2020
Marriott International	United States	Indonesia, Thailand	Opened two hotels in Indonesia and one in Thailand	2020
Matsumotokiyoshi	Japan	Viet Nam	Opened its first store in Viet Nam	2020
Meidi-Ya	Japan	Singapore	Inaugurated an outlet	2020
Muji	Japan	Viet Nam	Opened its first store in Viet Nam	2020
Philip Morris International	United States	Philippines	Opened its first four IQOS stores in the Philippines	2020
Uniqlo	Japan	Viet Nam, Indonesia	Opened stores in Viet Nam and Indonesia	2020

Sources: Company websites and media.

IT, digital economy and e-commerce

Even before the pandemic, many retailers and e-commerce companies have been establishing more digital facilities in the region, driven by the rapid growth of the digital economy. In 2019, fashion retailers LVMH (France) and Zara (Spain) expanded their online presence in Singapore and the Philippines, respectively, through the launch of proprietary e-commerce platforms, and Amazon (United States) launched an e-commerce platform in Singapore.

One notable impact of the pandemic is the shift towards greater use of online facilities such as in e-commerce, e-gaming, communication technology and e-health care (telemedicine). The pandemic accelerated the demand in 2020 for online activities, which encouraged further investment in digital-related businesses. Lockdown measures and health concerns motivated many retailers to expand or adopt digital platforms to support marketing and distribution.

In 2020, MNEs such as Ecco (Denmark), Honda Motor (Japan), and Seiko Epson (Japan) opened online stores on local and foreign-based e-commerce marketplaces in the Philippines and in Singapore. Some foreign MNEs, including Orbsat (United States), launched e-commerce marketplaces in Singapore, and PChome Online (Taiwan Province of China) opened a cross-border e-commerce platform in Viet Nam. Tibco Software (United States) launched a data management office in Viet Nam and Cint AB (Sweden), a market research technology services company, accelerated its presence in Asia-Pacific by opening an office in Singapore. Hakuhodo (Japan) launched a full-service digital agency providing a variety of digital marketing services in Viet Nam. Other foreign companies have also established digital or online facilities in the region (table 1.5).

Table 1.5. MNEs active in IT, digital economy and e-commerce with new investments or expansions in ASEAN, 2020
(Selected cases)

Company	Headquarters	Host country	Investment activity	Year
Hino Motors	Japan	Indonesia	Opened an online store on an e-commerce platform	2020
Kargo Global	United States	Singapore	Opened an office	2020
PCCW	Hong Kong, China	Malaysia	Opened a delivery centre	2020
Skyworth Group	China	Philippines	Opened an online store on an e-commerce platform	2020
TravelWifi	United States	Indonesia	Acquired a provider of mobile Wi-Fi solutions	2020
Unicommerce	India	Singapore, Indonesia	Opened offices	2020
UST Global	United States	Malaysia	Opened an innovation lab	2020

Sources: Company websites and media.

Digital infrastructure

The growing demand for efficient digital connectivity has led many MNEs to invest or participate in the development of 5G networks and establishment of data centres in ASEAN (chapter 3). Many Member States rolled out 5G licences in 2019–2020, and some completed trials of 5G networks in some areas in 2020. In 2019–2020, telecommunication MNEs such as Ericsson (Sweden), Huawei (China), Nokia (Finland), Ooredoo (Qatar) and ZTE (China) and regional players such as Axiata (Malaysia) and Viettel (Viet Nam) participated in 5G infrastructure projects in the region. Deutsche Telekom (Germany) inaugurated a cyberdefense and cybersecurity centre in Singapore in 2019, and Fortanix (United States) expanded its data security operations in 2020 by opening an office in Singapore.

Many data-centre MNEs and cloud companies have also set up operations across the region in 2019–2020. These companies include Alibaba Cloud (China), Equinix (United States), Google (United States) and SpaceDC (Singapore). In 2019, SAP (Germany) launched a data centre in Singapore which serves as the company's default location for clients in Southeast Asia and India. In 2020, Big Data Exchange (Hong Kong, China) completed the acquisition of its first overseas data centre, in Singapore, and Airtrunk (Australia) expanded in Asia with the inauguration of two hyperscale data centres, including one in Singapore.

Finance and banking

FDI in finance, the largest industry recipient in the preceding two consecutive years, fell by 11 per cent to $51 billion in 2020. MNEs were relatively active in 2019–2020 in both traditional and digital financial services (table 1.6). Singapore remained a key offshore financial centre for many MNE banks and also a regional hub for many venture capital firms because of increasing investment opportunities in an expanding pool of start-ups. The growing numbers of middle-income consumers and high-net-worth individuals in ASEAN have also continued to attract MNEs to invest or expand in financial services.

In 2019, Vulcan Capital Management (United States) opened its first international office in Singapore with an initial $100 million to be invested in start-ups in the region. JPMorgan Chase (United States) launched a trust company in Singapore to support clients in succession planning and wealth administration. In 2020, Standard Chartered (United Kingdom) and Citigroup (United States) inaugurated centres dedicated to high-net-worth individuals in Singapore. Asian banks and financial service providers pursued investments across the region. Korean banks were particularly active, opening operations in Cambodia, Malaysia and Viet Nam in 2019–2020.

Digital banking and fintech providers also expanded their regional footprints, in particular in digital payment solutions. In 2019, Allied Wallet (United Kingdom) opened an office in Thailand and PayPal (United States) launched a global customer operation centre in the Philippines. In 2020, iiPay (United States) opened an office in Singapore. Some insurance MNEs also invested in new offices in ASEAN Member States.

Table 1.6. Financial institutions MNEs with new investments or expansions in ASEAN, 2019 and 2020 (Selected cases)

Company	Headquarters	Host country	Investment activity	Year
Assicurazioni Generali	Italy	Viet Nam	Opened a branch and a regional office	2020
Backbase	Netherlands	Singapore	Launched a regional headquarters	2020
Barings BDC	United States	Singapore	Opened an office	2020
China Construction Bank	China	Malaysia	Opened a branch	2019
Europ Assistance	France	Thailand	Opened an office	2020
First Abu Dhabi Bank	United Arab Emirates	Indonesia	Opened a regional office	2020
Hamilton Lane	United States	Singapore	Opened an office	2020
Hayfin Capital Management	United Kingdom	Singapore	Opened an office	2020
Interactive Brokers	United States	Singapore	Opened an office	2020
KB Asset Management	Korea, Republic of	Viet Nam	Launched a representative office	2019
KB Kookmin Bank	Korea, Republic of	Cambodia	Opened a special bank branch	2020
Landesbank Baden-Württemberg	Germany	Indonesia	Opened a representative office	2019
Liberty Mutual Group	United States	Singapore	Opened an office	2020
Nihon M&A Center	Japan	Malaysia	Opened a representative office	2020

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Table 1.6. Financial institutions MNEs with new investments or expansions in ASEAN, 2019 and 2020 (Selected cases) (Concluded)

Company	Headquarters	Host country	Investment activity	Year
Nonghyup Bank	Korea, Republic of	Myanmar	Opened an office	2020
OneConnect Financial Technology	China	Malaysia	Launched a new entity	2020
Ontario Teachers Pension Plan	Canada	Singapore	Opened an office	2020
Shinhan Financial Group	Korea, Republic of	Viet Nam	Opened five local branches	2020
Shinkin Central Bank	Japan	Singapore	Established a wholly owned subsidiary	2020
Sun Life Financial	Canada	Singapore	Opened an office	2020
Vontobel Holding	Switzerland	Singapore	Opened an office	2020
Zurich Insurance	Switzerland	Malaysia	Opened a branch	2020

Sources: Company websites and media.

Infrastructure

Foreign MNEs continued to participate in the development of infrastructure in ASEAN such as in power, urban transportation and telecommunication projects (table 1.7, section 1.5.3 and section 1.5.4). Investments in renewable energy such as solar and hydropower plants, and wind farms attracted growing interest from power investors. Since the outbreak of the pandemic, Member States have been encouraging and accelerating implementation of more investment in infrastructure projects.

In 2019, Fujiwara (Japan) started commercial operation of a solar park in Viet Nam, and Engie Group (France) – with Sol Partners (Singapore) and a local partner (Mandalay Yoma Energy) – started operation of the biggest mini-grid in Myanmar. In 2020, Sharp Energy Solutions (Japan), together with local partners, completed a mega solar plant in Viet Nam, estimated to have the capacity to serve over 40,000 households. Doosan Heavy Industries & Construction (Republic of Korea) signed an agreement with Korea Western Power (Republic of Korea) to construct a hydroelectric power plant in the Lao People's Democratic Republic. Doosan Heavy Industries & Construction (Republic of Korea) is supplying steam turbines and other equipment to the Palu 3 power plant, which started construction in Indonesia in February 2020. Mitsubishi Power (Japan) is supplying gas turbines to a 1.4 GW natural gas-fired combined-cycle turbine facility, which is owned by Ratch Group and Gulf Energy Development in Thailand. Tokyo Electric Power and Chubu Electric Power (both Japan) are developing a $2 billion expansion of the Cirebon-2 1,000 MW ultra-supercritical coal-fired power generation plant in West Java, Indonesia. Construction of the plant is ongoing. Also in Indonesia, Sumitomo Corporation, Kansai Electric Power (both Japan) and a local partner are involved in the construction of a $4.4 billion re-expansion Tanjung Jati B power plant in Indonesia with commissioning expected in 2021. Mitsubishi Hitachi Power Systems and Toshiba Corporation (both Japan) are the equipment suppliers. In late 2020, SN Power (Norway) signed an agreement to acquire a wind farm plant in Viet Nam.

In Myanmar in 2020, a consortium of Marubeni, Sumitomo, Mitsui & Co (all Japan) and a local partner (Eden Group) received permission to proceed with construction of a $2 billion 1,250 MW liquefied natural gas (LNG) power plant. Hitachi (Japan) won a contract for the second phase of the National Electrification Project, and VPower Group (Hong Kong, China) and China National Technical Import and Export Corporation commissioned a 477 MW power plant in that host country. In the same year, the Government of Myanmar awarded many power projects to foreign MNEs. They included many Chinese companies such as Sungrow, China Machinery Engineering Corporation, China State Power Investment Corporation, Gezhouba Group and Xian Longi Clean Energy. A consortium of ib vogt (Germany) and Gold Energy (Myanmar) also won a power project in 2020.

In Singapore, in line with the growing trend in electric vehicles described earlier, ABB (Switzerland) won a contract to commission integrated smart charging points for automated guided vehicles in 2019 and Shell (United Kingdom-Netherlands) launched its first electric vehicle (EV) charging station in Singapore in the same year and plans to establish more such stations. Shell and Porsche (Germany) established a partnership in May 2021 to install a network of EV stations along the Malaysia's North-South highway. Nissan (Japan) and other leading car manufacturers are partnering with the Electricity Generating Authority of Thailand in March 2021 to establish EV charging stations in Thailand.

Other infrastructures were constructed across ASEAN Member States in 2019–2020. New airports are being developed or existing airports being upgraded. For instance, facilities at the Changi Airport in Singapore are being upgraded. In Cambodia, the construction of the $1.5 billion new Phnom Penh airport is being developed by a consortium led by Metallurgical Corporation (China) and other partners such as China State Construction Engineering and Fosters & Partners (United States). In Lao People's Democratic Republic, Chinese companies are near completion in constructing a high-speed train line, which involved construction of tunnels and bridges. These companies include the China Railway Group consortium, which involved China Railway No.2 Engineering Group, China Railway No.5 Engineering Group and China Railway No.8 Engineering Group.

Table 1.7. MNEs investing in new or expanding infrastructure projects in ASEAN, 2019 and 2020 (Selected cases)

Company	Headquarters	Host country	Investment activity	Year
DB Schenker	Germany	Singapore	Started operation of a regional hub for automated high-speed logistics	2020
Gunkul Engineering	Thailand	Viet Nam	Bought several solar plants	2020
Hankyu Hanshin Properties	Japan	Viet Nam	Bought a stake in a logistics property joint venture	2020
Nippon Telegraph and Telephone	Japan	Myanmar	Launched a subsidiary	2020
NTT	Japan	Indonesia	Started construction of a data centre	2019
Sankyu	Japan	Thailand	Opened a logistics base	2020

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Table 1.7. MNEs investing in new or expanding infrastructure projects in ASEAN, 2019 and 2020 (Selected cases) (Concluded)

Company	Headquarters	Host country	Investment activity	Year
Scatec	Norway	Malaysia	Reached commercial operation of a solar power plant	2020
Siemens	Germany	Singapore	Opened its Advance Manufacturing Transformation Center	2020
SSI Schaefer	Switzerland	Philippines	Opened a cold chain storage facility	2020
Suez Group	France	Philippines	Awarded a design and construction contract for a sewage treatment plant	2020

Sources: Company websites and media.

(e) Research and development

MNEs in different industries continued to establish research and development (R&D) centres in 2019–2020, including centres of excellence for the development and application of Industry 4.0 technologies (chapter 3 and 4). In 2019, chemicals MNEs Clariant (Switzerland) started an engineering service centre in Thailand to support clients in Asia-Pacific, and Tejin (Japan) launched a third resin-related R&D hub in Thailand. In 2020, BASF (Germany) established an ASEAN technical development centre in Thailand, which will also provide technical support to its customer networks in China, Germany and the Republic of Korea. In electronics, STMicroelectronics (Switzerland) opened an R&D facility in Singapore in 2020 and Qualcomm (United States) inaugurated an interoperability testing laboratory in Viet Nam to support local original equipment manufacturers. Also in Viet Nam, Samsung (Republic of Korea) started building a $220 million R&D centre dedicated to artificial intelligence, the internet of things, big data and 5G. In the pharmaceutical industry, in Singapore Neogenomics (United States) opened an oncology-focused clinical trials testing lab in 2019 and Clinuvel Pharmaceutical (Australia) started a R&D centre in the same host country in 2020. In the information technology industry, Toyota Tsusho (Japan) and partner companies established a centre in Singapore for R&D in technologies such as machine learning and mathematical optimization technology for mobility projects. In late 2020, Zoom Video Communications (United States) expanded its operations in Singapore by opening an R&D centre. In agriculture, Mondelez International (United States) launched in 2020 a technical centre focused on cocoa crop science in Indonesia to support cocoa farming practices.

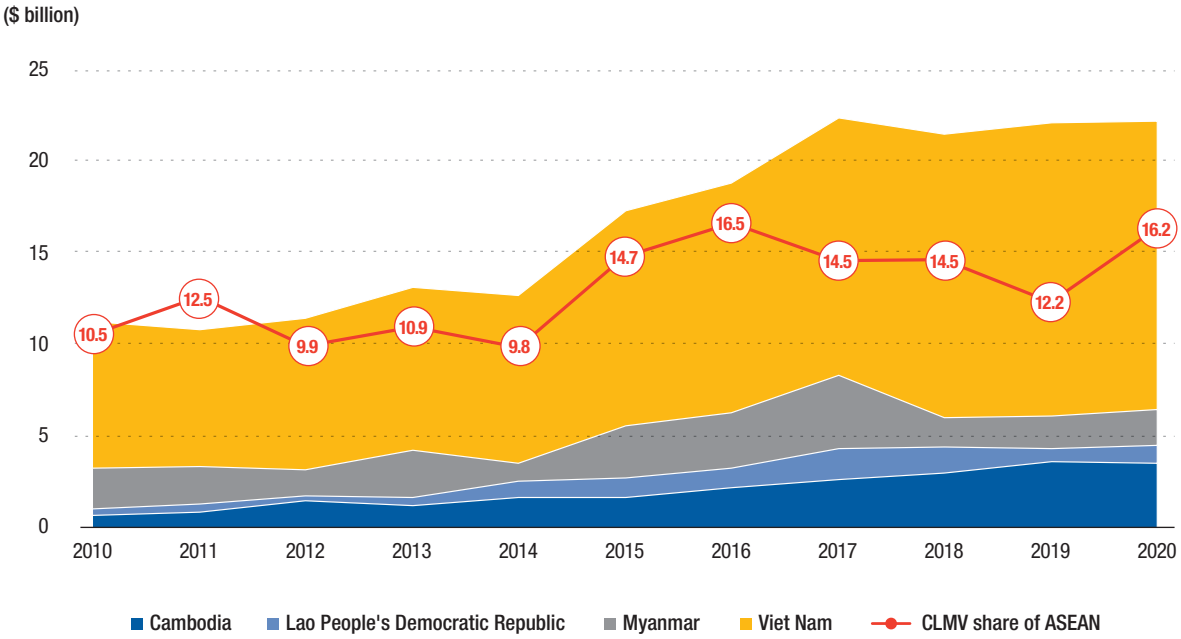
(f) Regional strategies and headquarters

A few ASEAN Member States continued to attract investment in regional headquarters. In 2019–2020, Kargo Global and iiPay (both United States), Total Group (France), Deutsche Messe (Germany), Mitsubishi Chemical and Mitsui Knowledge Industry (both Japan) opened regional headquarters in Singapore to coordinate their Asia-Pacific and ASEAN operations. In Malaysia, OPPO (China) established its fourth regional operations centre in 2019 to support its regional expansion. In 2020, Volvo (Sweden) launched a $32 million warehouse in Thailand as a one-stop hub in ASEAN and Yamaha Motors (Japan) opened an office to serve as its regional headquarters to strengthen the robotics business in the region (e.g. semiconductor manufacturing equipment and industrial robots).

1.3. FDI IN CLMV COUNTRIES

FDI in the CLMV countries was flat at $22 billion, but the group's share of FDI inflows in ASEAN rose from 12.2 per cent in 2019 to 16.2 per cent in 2020. Viet Nam remained the largest recipient, accounting for nearly 70 per cent of investment in the group in 2010–2020 (figure 1.7). Robust investment in manufacturing, finance and infrastructure-related activities were key drivers. Asian investors (e.g. from ASEAN, China, Japan and the Republic of Korea) remained major sources of investment for the group.

Figure 1.7. CLMV countries: FDI flows and share of FDI in ASEAN, 2010–2020
(Billions of dollars and per cent)



Source: ASEAN Secretariat, ASEAN FDI database.

Cambodia

In 2019, Cambodia attracted all-time high FDI inflows at $3.6 billion because of a 50 per cent and 16 per cent rise in investment in manufacturing and finance, respectively. In 2020, FDI was flat at $3.6 billion, thanks to inflows in finance, which rose by 13 per cent to $1.4 billion, compensating for a 12 per cent fall in manufacturing. Investment in industries such as hospitality and real estate declined. The slump in international garment orders or cancellation of purchases by clothing retailers was a major reason affecting FDI in garments. National measures restricting movement of people and concern about the economic slowdown affected investment in the hospitality and the real estate industries.

Asia (e.g. ASEAN, China, Hong Kong (China), Japan, Taiwan Province of China) remained the largest source of FDI, accounting for more than 80 per cent of inflows in 2019–2020. China continued to be the largest source of investment followed by ASEAN.

Lao People's Democratic Republic

FDI in the Lao People's Democratic Republic rose 28 per cent to $968 million, driven by investments in hydropower. International project finance deals in that country nearly quadrupled in 2020 to $3.3 billion, to be invested over several years. Asia investors, particularly from China and ASEAN, continued to be major sources of investment for the country.

Myanmar

FDI in Myanmar rose from $1.7 billion in 2019 to $1.9 billion. The country continued to receive investor attention in a wide range of industries, including in manufacturing and extractive activities. China remained a major investor but intra-ASEAN investment in Myanmar fell from $1.2 billion in 2019 to $0.9 billion.

Viet Nam

FDI in Viet Nam has been growing steadily since 2014. Despite the pandemic, inflows in the country were resilient and stable at $16 billion, thanks to the successful efforts to contain the pandemic in 2020. Companies from Asia remained the largest source of FDI. Investment from ASEAN topped the list, with companies from Singapore accounting for more than 40 per cent of inflows in 2020. A significant rise in FDI from Singapore, from just $2 billion in 2019 to $5 billion, cushioned the decline in investment from traditional sources such as the Republic of Korea and Japan, and from China and Hong Kong (China). Intra-ASEAN investment was the highest ever recorded in Viet Nam.

Two industries (manufacturing and electricity) accounted for more than 60 per cent of FDI in 2020. Although manufacturing continued to be the largest recipient, FDI in that industry fell by more than 28 per cent, from $10 billion in 2019 to $8 billion. The decline was compensated by an increase in investment in electricity to $3 billion. Asian investors were active in these two key industries.

Concerns about the pandemic and the economy led to a significant drop in investment in real estate to $2.3 billion. Real estate had been the second largest recipient of FDI in 2019, replaced by electricity in 2020.

1.4. INTRA-ASEAN INVESTMENT AND ENTERPRISE REGIONALIZATION

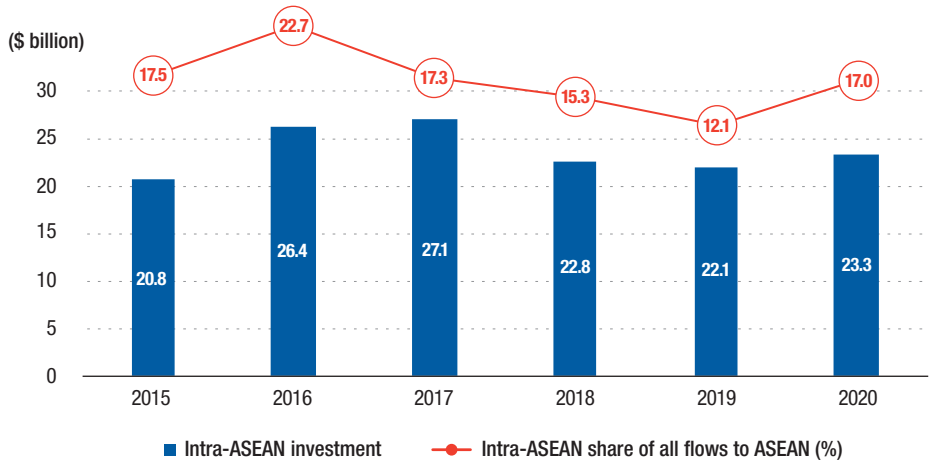
ASEAN MNEs continued to internationalize during the pandemic but with lower levels of investment. Outward FDI from the region decreased by 16 per cent to $61 billion, primarily because of a 32 per cent drop in investment from Singapore to $32 billion. However, the region's share of global outward investment flows rose from 6 per cent in 2019 to 8 per cent – highlighting that the region is a growing source of international investment, particularly intraregionally.

Firms from Singapore remained the region's largest investor in 2020, followed by those from Thailand. A significant amount of investment from these two and other ASEAN Member States is made within the region. Outward FDI (OFDI) from Thailand rose by 78 per cent, from $10 billion in 2019 to an all-time high of $18 billion. This underscores the growing appetite of Thai companies to internationalize to expand their market, particularly in ASEAN. Thai MNEs have also been active in acquiring assets abroad, with their cross-border M&A purchases more than doubling to $17 billion in 2020. About 70 per cent of OFDI from that country was in financial services, manufacturing, and wholesale and retail trade. More than 37 per cent of Thai OFDI and nearly 45 per cent of Singapore OFDI in 2020 was in ASEAN. OFDI from Indonesia and from the Philippines to the world each rose to $4 billion, from $3 billion in 2019.

1.4.1. Intra-ASEAN investment

While most major sources of FDI in ASEAN fell, intra-ASEAN investment was resilient. It rose by 5 per cent to $23 billion, pushing up the intra-ASEAN share of FDI in the region from 12 per cent to 17 per cent (figure 1.8). Three aspects of continuing regional dynamics play a role in supporting investment in intraregional investment. First, regional integration and emerging investment opportunities encourage ASEAN companies to internationalize in the region to expand markets and to increase efficiency. Geographical and cultural proximity and affinity favour early stages of internationalization to neighbouring countries. Second, the support of Member States for corporate regionalization is an important factor. Many investment promotion agencies (IPAs) in the region promote awareness of ASEAN agreements, regional integration and their implications for business and investment opportunities to home-country investors. Third, the continuation of regional division of labour by ASEAN MNEs relocating from higher-cost or labour-constrained markets to lower-cost or labour-abundant locations (e.g. the CLMV countries and Indonesia).

Figure 1.8. Intra-ASEAN investment flows and shares, 2015–2020 (Billions of dollars and per cent)



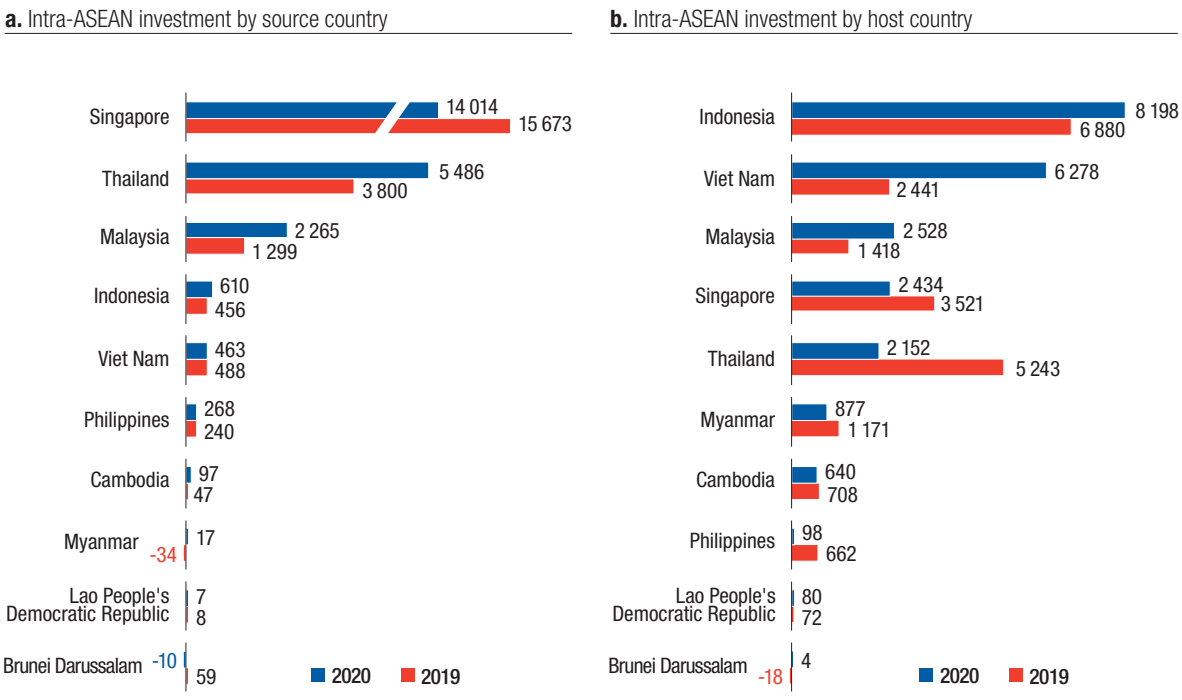
Source: ASEAN Secretariat, ASEAN FDI database.

(a) Intra-ASEAN investment sources

Intra-ASEAN investment is typically highly concentrated, coming from a few source countries. Companies from two Member States (Singapore and Thailand) provided 84 per cent of all intra-ASEAN investment in 2020 (figure 1.9a); four Member States (Indonesia, Viet Nam, Malaysia and Singapore in that order) received 83 per cent of all such investment. Thai companies are increasingly active regional investors, overtaking the historical second position of Malaysian companies. Thai investment within ASEAN in 2020 was the highest recorded.

Investment in ASEAN from Singapore fell 11 per cent in 2020 to $14 billion but was cushioned by a rise in intraregional investment, mainly from four Member States (Thailand, Malaysia, Indonesia and the Philippines). Despite the fall, Singapore remained a significant source of investment for many Member States, as companies from that country accounted for more than 25 per cent of FDI in Indonesia and 32 per cent in Viet Nam. Companies from Singapore were the largest investor group in Member States such as Indonesia, Thailand and Viet Nam.

Figure 1.9. Intra-ASEAN investment, by source and host country, 2019–2020 (Millions of dollars)



Source: ASEAN Secretariat, ASEAN FDI database.

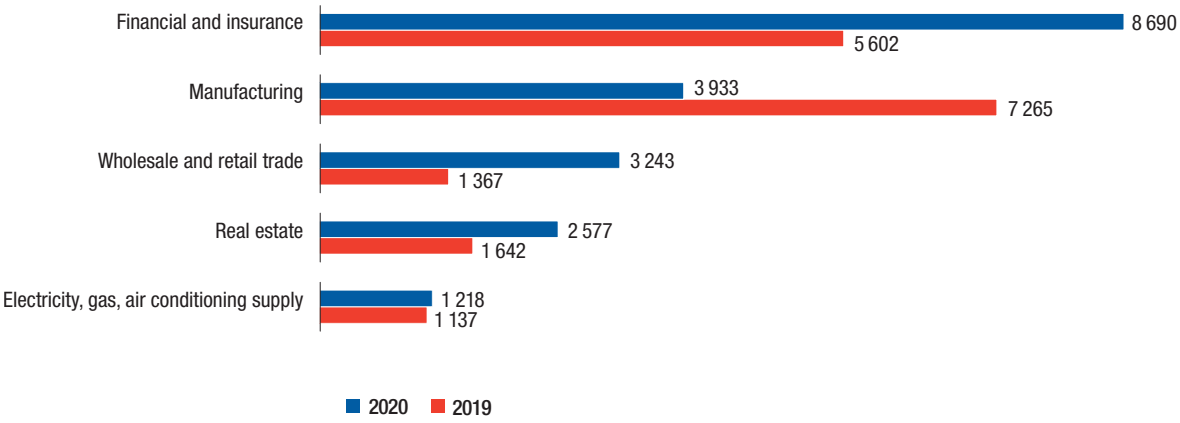
A significant portion of intra-ASEAN investments originate from outside the region and channeled through a few Member States, mostly from Singapore. Excluding such conduit investment, the share of intraregional investment falls significantly.[5]

(b) Intra-ASEAN investment recipients

Firms from three Member States (Indonesia, Viet Nam and Malaysia) accounted for 73 per cent of intraregional investment in 2020, and all three countries received more intra-ASEAN investment than in 2019 (figure 1.9b). In Indonesia, the largest recipient, intra-ASEAN investment rose by 19 per cent to $8.2 billion. Intraregional investment in Viet Nam rose 2.6 times to a record $6.3 billion. Singapore, traditionally a major recipient of intra-ASEAN investment, saw such investment fall by 31 per cent to just $2.4 billion – the second lowest level recorded since 2010.

Intra-ASEAN investment to the top five industries, other than manufacturing, rose from $17 billion to $18.5 billion, pushing up the share of these industries in intraregional investment from 77 per cent to 80 per cent (figure 1.10). Strong intraregional investment in finance and in wholesale and retail trade were the key drivers sustaining the rise. The significant decline in intraregional manufacturing investment – from $7.3 billion in 2019 to $3.9 billion, primarily by companies headquartered in Singapore – was a key reason for intraregional manufacturing investment to falter. Companies from Singapore accounted for 88 per cent of intraregional manufacturing investment in 2019–2020.

Figure 1.10. Intra-ASEAN investment by industry, 2019 and 2020 (Millions of dollars)



Source: ASEAN Secretariat, ASEAN FDI database.

Some specific corporate activities led to a significant rise in Thai investment in ASEAN and help sustained Singapore's strong intraregional investment. Thai companies are actively investing in finance, construction of power plants and in retail activities. For instance, in Viet Nam, EGAT and the Electricity Generating Company are building a $2.4 billion power plant, Super Energy is constructing the $384 million Loc Ninh power plant, and B. Grimm Power is involved in a $300 million solar power project. Thai companies completed five M&A megadeals exceeding $500 million (section 1.2.1).

In the case of Singapore, investment in manufacturing and finance in neighbouring Member States – the two largest industry targets in ASEAN – fell by 42 per cent and 18 per cent to $4 billion and $2.7 billion respectively. The declined in investment in these two industries was cushioned to an extent by a significant rise in intraregional investment in wholesale and retail trade (1.5 times to $2.0 billion) as more digital start-ups based in Singapore regionalize their activities with funding raised from venture capital companies and other funding corporations (*AIR 2019* and chapter 4).

Some Member States have been receiving more than 50 per cent FDI from sources within the region (e.g. Myanmar and Thailand in 2019–2020), underpinning increasing investment and production connectivity and regional value chain dynamics. This is led by growing relocation of production from higher cost locations to lower cost Member States such as the CLMV countries – bridging the development gap between the Member States through investment and production. This regional division of labour is prominent in industries such as garments, footwear and labour-intensive operations in electronics and machinery. Regional cooperation and public-private partnership initiatives are also bolstering intraregional investment (box 1.1).

Box 1.1. Institutional support for regional manufacturing activities

Singapore launched the Southeast Asia Manufacturing Alliance in February 2021 to promote a network of industrial parks in ASEAN to manufacturers interested in investing in both Singapore and other countries in the region.[a] The alliance involves the EDB, Enterprise Singapore and several private sector players in the manufacturing industry. Global manufacturers will be able to use a network of industrial parks within Singapore and Southeast Asia to benefit from the complementary advantages of different locations, expand supply chains and grow their manufacturing footprint in the region.

Three Singapore industrial park developers (CapitaLand, Sembcorp and Gallant Venture) participated in the alliance. They operate more than 10 industrial parks in Indonesia, Malaysia and Viet Nam. Companies interested in investing in both Singapore and industrial parks owned by CapitaLand in Iskandar Malaysia will be eligible for benefits (e.g. business facilitation, supplier matching services and Industry 4.0 pilot implementation) provided by CapitaLand, EDB and Enterprise Singapore.

Source: Economic Development Board (EDB).
[a] EDB, "Launch of the Southeast Asia Manufacturing Alliance", press release, 3 February 2021.

1.4.2. Intra-ASEAN MNE activities

The rise in intraregional investment even during pandemic situation is underscored by active investment activities of ASEAN companies across a wide range of industries, particularly in finance, manufacturing, wholesale and retail, real estate and power generation. The rise in intra-ASEAN MNE activities continued to be underpinned by expansion of facilities in the same host country and expansion to other Member States. The cases below highlight some intra-ASEAN investment activities in a wide range of industries that started operation or with construction started in 2019 and 2020.

(a) Agriculture

Wilmar (Singapore) started operating an edible oil packaging plant in Myanmar in 2019. In the same year, Leong Hup International (Malaysia) completed the construction of a $2 million hatchery in the Philippines and added a grain drying facility at one of its existing plants in Viet Nam, while Kuala Lumpur Kepong (Malaysia) commenced operations of a new palm oil mill in Indonesia. In 2020, Japfa Comfeed (Indonesia) inaugurated a $13 million feed mill in Viet Nam, its 16th facilities in the country. Charoen Pokphand Foods (Thailand) opened a $250 million chicken processing plant in the same host country. Leong Hup International (Malaysia) with already numerous agriculture facilities in Viet Nam, further expanded in the Philippines with the construction of a $14 million feed mill plant. In Indonesia, Kuala Lumpur Kepong (Malaysia) expanded palm oil operation with construction of a new palm oil mill and Genting Plantation (Malaysia) opened a fifth palm oil mill. Olam International (Singapore) started expansion of one of its dairy facilities in Malaysia.

(b) Energy and mining

Intra-ASEAN investment in energy and mining fell from $965 million in 2019 to $696 million. In 2019, Phoenix Petroleum (Philippines) established a subsidiary for liquified petroleum gas business in Viet Nam and acquired Origin LPG Viet Nam for $16 million. The investment motive was to trade and distribute liquified petroleum gas in that host country. PT Pertamina (Indonesia) opened a trading and marketing subsidiary in Singapore. In 2020, PetroVietnam Drilling & Well Services Corporation (Viet Nam) established a branch in Brunei Darussalam to be close to drilling clients in that host country. Sembcorp Industries (Singapore), Becamex IDC Corporation (Viet Nam) and the Viet Nam–Singapore joint venture, Industrial Park JV Co, established a headquarters (Viet Nam-Singapore Smart Energy Solutions) in Viet Nam to develop and implement rooftop solar and other energy solutions.

(c) Manufacturing

Intra-ASEAN manufacturing investments were the most pandemic impacted industry. Intraregional manufacturing FDI fell by 41 per cent to $4.3 billion because of a 35 per cent fall in investment to $4 billion by companies based in Singapore in this industry. This suggests a robust production connectivity between companies based in Singapore and the region.

Despite the decline, many ASEAN MNEs continued to invest or expand in the region in different manufacturing industries, but not sufficient to pull up the overall intraregional manufacturing investment. In 2019, Siam GS Battery (Thailand) and GS Yuasa International (Japan) launched a $10 million battery charging factory in Myanmar. Global Invacom, a communication equipment manufacturer, headquartered in Singapore inaugurated a new subsidiary in Jakarta to support sales and marketing activities across the region. In 2020, Thai Union (Thailand) set up a new subsidiary in Singapore to tap into potential acquisition opportunities in the food-technology industry. Olam (Singapore) completed a new plant that combines a nuts packaging facility and a R&D unit. Fraser & Neave (Singapore), which is ultimately owned by a Thai conglomerate, started operation of a new ice cream plant in Thailand and started construction of a new integrated warehouse in Malaysia. Karex (Malaysia) started construction of

a $9.5 million glove manufacturing facility at its existing plant in Thailand. TOA-Chugoku Paints, a joint venture between TOA Paint (Thailand) and Chugoku Marine Paints (Japan) launched their first $9.6 million overseas plant in Myanmar.

(d) Services

While still affected by the pandemic, services fared better in intraregional investment with most major industries witnessing a rise in intra-ASEAN investment (e.g. finance, wholesale and retail, real estate and construction).

Finance and banking

Both traditional ASEAN financial institutions and digital financial service providers continued to expand regionally in 2019–2020. In 2019, VietinBank (Viet Nam) opened a banking unit in the Lao People's Democratic Republic and HD Bank (Viet Nam) opened its first representative office in Myanmar. In 2020, RHB Bank (Malaysia) inaugurated its first Premier Banking Centre in Cambodia to offer premium services for high-net-worth individuals. Siam Commercial Bank (Thailand) started operation of a wholly owned subsidiary bank in Myanmar. In 2020, some ASEAN fintech companies diversified operations in the region. For example, Fomo Pay (Singapore), a digital payment solution provider partnered with OCBC Bank (Malaysia) to develop a QR code payment system having opened an office in Malaysia earlier in the year. Emas Fintech (Philippines), an investment fund operator, opened its first regional support centre in Malaysia.

Wholesale and retail

ASEAN companies were relatively active in retail businesses, particularly in supermarket operation in the region. In 2019, Thai supermarket chain Big C opened its first store in Cambodia with a $6.8 million facility. Binh Tien Imex, a Vietnamese footwear brand, and Mobile World Investment Corporation (Viet Nam), a retailer specialized in computer and electronics, opened a store each in Cambodia. Some ASEAN food retailers also expanded in the region. Filipino ice cream brand Carmen's Best opened its first overseas store in Singapore and Ryan's Grocery (Singapore) launched an operation in Ho Chi Minh, Viet Nam. In 2020, Banyan Tee Group (Singapore) inaugurated ORI9IN, a gourmet organic farm in Thailand. PTT (Thailand) expanded its Café Amazon chain with a first store in Viet Nam. Smartbite (Malaysia) expanded its food catering operation and Zen Rooms (Singapore), a budget and mid-range hotel franchise, relocated its regional operational headquarters to the Philippines. Siam Makro (Thailand), a cash and carry operator, opened it first store in Myanmar. A Thai investor group acquired Tesco stores in Malaysia for $700 million.

Digital services

Companies providing digital services and especially those active in e-commerce experienced a boom in activities during the pandemic as consumers and businesses moved towards digital solutions to buy goods and services, and to reach out to markets.

In 2019, RedDoorz, a hotel management and booking platform inaugurated a new regional technology hub in Viet Nam. True Digital Group (Thailand), a wholly owned subsidiary of True Corporation (Thailand) established a new office in Indonesia to provide digital solutions and data

analytics in the country. In 2020, J&T Express, an Indonesian e-commerce logistics provider opened its third warehouse in Singapore. Thai-based fashion e-commerce company Pomelo opened its first store in Indonesia. Social Bella (Indonesia), a beauty technology company, completed its first overseas expansion with the launch of an e-commerce platform in Viet Nam. In the same year, True Digital Group established another subsidiary in Viet Nam and Tellscore, a Thai integrated marketing service provider, expanded to Indonesia.

Infrastructure

ASEAN MNEs continued to expand in infrastructure activities including in construction of new power plants through investments and contractual arrangements (see section 1.5.3). In 2019, Mandalay Yoma Energy, a joint venture between Sol Partners (Singapore) and Engie Group (France) inaugurated the largest mini-grid in Myanmar. B.Grimm (Thailand) together with a local partner completed a $391 million solar power complex in Viet Nam. In 2020, New Growth BV, a wholly owned subsidiary of Electricity Generating Public (Thailand) inaugurated a $1.1 billion coal-fired power plant in the Philippines through a joint venture with Manila Electric (Philippines). AC Energy (Philippines), the power generating arm of Ayala Corporation (Philippines), started construction of a 210 MW wind farm in Viet Nam and Gunkul Engineering (Thailand) acquired several solar energy projects in the same host country. A subsidiary of Bangchak Corporation (Thailand) is building a 600 MW wind farm in Lao People's Democratic Republic. In the same year, Gulf (Thailand) is constructing wind farms and a gas-fired power plant in Viet Nam and is negotiating three hydro power plant projects in Lao People's Democratic Republic.

1.5. MAJOR DEVELOPMENTS SHAPING THE FDI LANDSCAPE

The year 2020 also saw a few major developments, which will or continue to shape the region's FDI landscape. These developments include the following:

(i) Signing of the RCEP Agreement, which establishes the world largest free trade area (chapter 2).

(ii) Continued diversification of FDI by MNEs to ASEAN. The diversification already happening before the outbreak of the pandemic because of rising cost in China and impact of the United States-China trade tensions. The pandemic and the supply chains disruption in 2020 accelerated the process of diversification. As MNEs undertake FDI to strengthen resilience in Asia, ASEAN Member States are expected to be major beneficiaries.

(iii) Adoption of measures favourable to FDI in relation to pandemic responses by Member States and through the 2020 ASEAN Comprehensive Recovery Framework (chapter 2).

(iv) Accelerated implementation of national infrastructure plans and growth in digital infrastructure that opens up more opportunities to MNEs. The rapid growth of the digital economy has attracted increasing investor interests. The region's push for Industry 4.0 transformation and development of related enabling industries (5G and data centres) have also attracted growing attention from digital MNEs (chapter 4).

(v) The continued growth of Chinese FDI and non-equity forms of investment in the region.

1.5.1. RCEP FDI trend in ASEAN

The RCEP Agreement was signed in November 2020 by all ASEAN Member States plus Australia, China, Japan, the Republic of Korea and New Zealand. The RCEP will have significant implications for ASEAN for attracting FDI in the post-pandemic recovery period. This is best examined in terms of the economic significance of the RCEP, how the group is important to ASEAN and RCEP MNE activities in the region.

(a) Significance of RCEP

The RCEP is the world's largest free trade area in the making. It comprises a diverse group of high-, medium- and low-income economies, which together account for 30 per cent of the world's population, gross domestic product (GDP) and merchandise exports. It contains 4.5 times as many people as covered by the Comprehensive and Progressive Agreement of the Trans-Pacific Partnership and more than 5 times as many as the European Union. The grouping is a major destination for international investment and production, as well as home to many global MNEs in a wide range of industries (e.g. electronics, semiconductors, automotive, garment, e-commerce, technology). The RCEP member countries constitute a major hub of global value chains (GVCs) and a manufacturing powerhouse. About half of the world's manufacturing output and global automotive production and as much as 70 per cent of electronics are produced in RCEP member countries.

The RCEP will shape further GVC activities and FDI for supply chain resilience. Most RCEP countries are highly integrated in GVCs. The group accounts for 26 per cent of world GVC trade volume (including goods and services) and trade in intermediate goods is rapidly growing both within RCEP and with non-RCEP countries. The volume of GVC trade of RCEP countries increased by 34 per cent between 2010 and 2018. Intraregional value chain trade is growing even faster. This represents a growth of 50 per cent over the 2010 level. The potential for RCEP to support further intraregional value chain growth could be especially important in light of the expected shifts in regional trade and investment patterns as a result of the trade tensions affecting China as well as post-pandemic supply chain diversification and resilience-seeking investment trends.

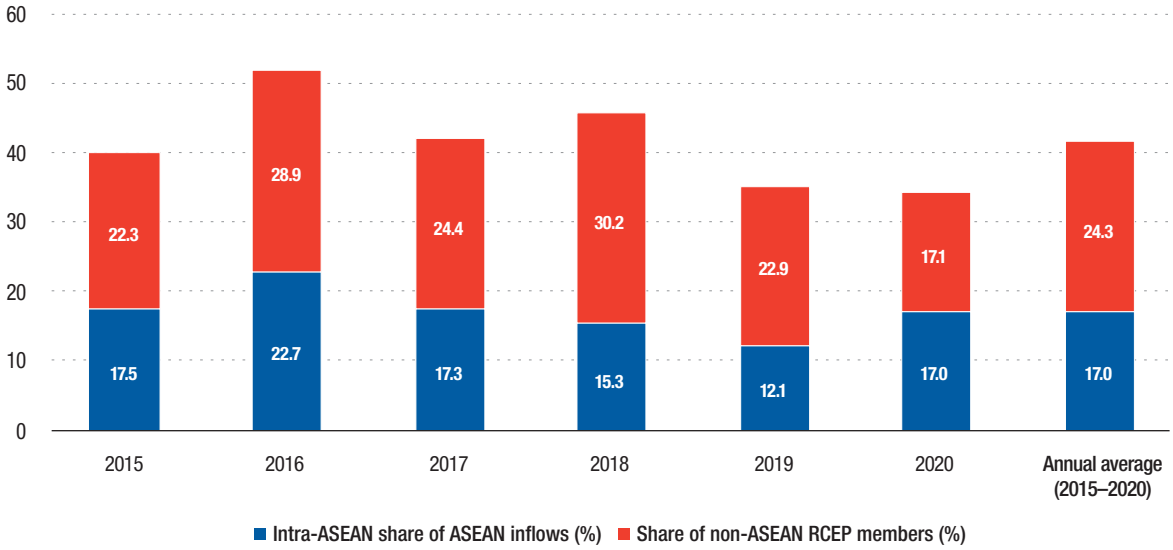
In investment, some 15 per cent of global FDI stock and more than 33 per cent of flows in 2020 are in RCEP. While global FDI has been stagnant for the last decade, the group witnessed an upward investment trend until 2020. Growing annual inflows pushed up FDI stock in the group from $2.7 trillion in 2010 to $6.2 trillion in 2020, an average growth rate of 9 per cent per year. The group is a major destination for global investment flows.

In outward FDI, the group accounted for 48 per cent of global FDI outflows in 2020, up from just 17 per cent in 2010. The rise in outflows pushed up outward FDI stock, from $2.4 trillion in 2010 to $7.1 trillion in 2020 – more than twice the growth rate of global FDI outward stock in the same period. RCEP is an important and growing source of global FDI.

Investment and production connectivity among RCEP countries is robust. Intraregional investment, at about 30 per cent of total FDI in RCEP, has significant room for further growth.

It is relatively low compared to other major economic partnerships. The ASEAN group, at the heart of RCEP, will play an important role. Already about 40 per cent of investment in ASEAN comes from RCEP members (figure 1.11). There are opportunities for greater connectivity through investment, production and intrafirm transactions in ASEAN and between ASEAN and the non-ASEAN RCEP members.

Figure 1.11. RCEP members share of FDI in ASEAN, 2015–2020 and annual average, 2015–2020 (Per cent)



Source: ASEAN Secretariat, ASEAN FDI database.
Note: Non-ASEAN RCEP members refer to Australia, China, Japan, Republic of Korea and New Zealand.

Given the diversity and economic significance of the RCEP members, the group can be a major magnet for attracting FDI and for MNEs to build resilient regional production networks. The RCEP is important not only for intraregional investment but also as a trade and investment block for the rest of the world. About 70 per cent of FDI inflows to RCEP economies come from non-RCEP economies.

(b) Significance of RCEP as a source of FDI to ASEAN

The RCEP accounts for 40 per cent of FDI inflows in ASEAN, of which 24 per cent are from non-ASEAN RCEP members. More than 95 per cent of FDI from non-ASEAN RCEP countries in 2018–2020 was from Japan, China and the Republic of Korea, in that order. Investment in ASEAN from RCEP countries, with the exception of China, is highly concentrated in three key industries (table 1.8). The top three industries are similar for ASEAN, Japan and the Republic of Korea (i.e. manufacturing, finance, and wholesale and retail trade). ASEAN real estate is a significant target for investment from China, whereas professional, scientific and technical services are significant targets for investment from Australia.

Table 1.8. RCEP FDI in ASEAN, selected indicators, 2018–2020 (Billions of dollars and per cent)

Indicator	ASEAN	Australia	China	Japan	Korea, Republic of	New Zealand
Annual average FDI, 2018–2020 ($ billion)	22.7	0.8	9.8	19.7	6.5	0.03
Top three industries	Manufacturing Finance Wholesale and retail trade	Wholesale and retail trade Professional, scientific and technical services Finance	Real estate Manufacturing Wholesale and retail trade	Manufacturing Finance Wholesale and retail trade	Manufacturing Wholesale and retail trade Finance	Wholesale and retail trade Manufacturing Finance
FDI in top three industries ($ billion)	15.3	0.7	5.5	14.7	4.9	0.04
Share of top three industries of respective RCEP countries in ASEAN (%)	67.3	94.0 (because of -$0.3 billion in manufacturing)	56.9	74.8	75.9	..

Source: ASEAN Secretariat, ASEAN FDI database.

For agriculture, intra-ASEAN investment is important, accounting for 83 per cent of all FDI in agriculture in the region during 2018–2020 (table 1.9). Of all RCEP members, ASEAN and Japan are the major investors in manufacturing. In electricity and power generation activities, ASEAN, China, Japan and the Republic of Korea account for more than 70 per cent of FDI. Firms from China and ASEAN are active investors in real estate in the region; in finance, investment from ASEAN and Japan is more prominent than investment from other RCEP members. Firms from China are the leading source of investment in ASEAN in both the construction and the information and communication industries.

Table 1.9. Share of lead RCEP investors in selected industries in ASEAN, annual average, 2018–2020
(Per cent and millions of dollars)

	Share (%)						
Industry	**ASEAN**	**Australia**	**China**	**Japan**	**Korea, Republic of**	**New Zealand**	**FDI, annual average ($ million)**
Agriculture, forestry and fishing	82.9	..	12.6	..	..	..	2 208
Manufacturing	14.6	..	4.6	15.6	6.0	..	44 559
Electricity, gas, air conditioning	35.3	..	17.9	9.3	9.1	..	2 450
Construction	10.0	..	27.2	15.6	..	..	2 500
Wholesale and retail trade	12.2	1.6	5.4	9.3	5.9		24 529
Transportation and storage	..	..	25.6	63.9	..	..	1 743
Information and communication	22.0	3.9	40.0	..	..	..	2 349
Finance and insurance	12.0	..	2.4	10.8	1.7	..	46 732
Real estate	18.9	..	22.0	7.0	4.8	..	9 725

Source: ASEAN Secretariat, ASEAN FDI database.
Note: .. = negligible.

(c) Top 100 MNEs from non-ASEAN RCEP member countries

The top 100 MNEs from non-ASEAN RCEP member countries are active in the region. Some have been operating in ASEAN for many decades, such as MNEs from Australia *(AIR 2018),* Japan *(AIR 2014)* and the Republic of Korea *(AIR 2016).* Chinese MNEs are relatively recent players. Significant numbers of private Chinese MNEs have been actively establishing a presence in ASEAN in recent decade.

These top 100 hold more than $1.1 trillion in cash or near cash items and $13.6 trillion in assets in 2019. They have significant investment firepower and potential to further invest in ASEAN in new, expansion and diversification activities. Nearly all of the top 100 are headquartered in three countries (China, Japan and the Republic of Korea) (table 1.10). MNEs from Japan and the Republic of Korea have operations in six or more ASEAN Member States, as compared with MNEs from China, which have operations in only three. A major difference is that on average, Japanese and Korean MNEs have been in the region much longer than Chinese MNEs. Over time, MNEs from Japan and the Republic of Korea have expanded to more ASEAN countries, to establish a stronger regional footprint and build up intrafirm and interfirm activities. Yet the number of Korean firms in the top 100 is relatively small. In terms of value, most Korean FDI in ASEAN is by large companies, although investment by small and medium-size enterprises (SMEs) is rising *(AIR 2019).*

In contrast, most Chinese MNEs in the top 100 are State-owned enterprises, mostly operating in activities related to real estate, construction and infrastructure – influenced by the Belt and Road Initiative (BRI) – whereas MNEs from Japan and the Republic of Korea operate more in manufacturing and services. Investment by Chinese MNEs in manufacturing in ASEAN is small but growing. Australian MNEs in ASEAN are mainly in the extractive industries. Australian MNEs outside the top 100 are also active investors in the region (*AIR 2018,* box 1.2).

Table 1.10. Top 100 MNEs from non-ASEAN RCEP member countries, selected indicators by home country, 2020

	Australia	China	Japan	Korea, Republic of
Number of MNEs in ASEAN	1	65	27	7
State-owned enterprises	..	46	..	1
Presence in ASEAN (average number of countries)	4	3	6	7
Top three industries	Mining and extraction	Real estate, business services, construction	Wholesale, transport manufacturing, communications	Transport manufacturing, industrial, electronics

Source: Annex table 1.1.
Note: No MNEs headquartered in New Zealand are in the top 100.

Box 1.2. Australian MNEs in ASEAN

Australia has longstanding economic and investment ties with ASEAN, dating back to at least the 1850s. In the early 20th century, Australia MNEs participated in Malaysia's tin and rubber industry. The investment relationship between Australia and ASEAN today is strong and growing.

Some 60 of the 100 largest Australian companies have subsidiaries in ASEAN. These companies are involved in a wide range of industries, from extractives and manufacturing to services. Finance and extractive MNEs dominate the list. The strength of Australian MNEs in these industries and their drive towards internationalization, together with investment opportunities and the geographical proximity of ASEAN, have contributed to this investment pattern. The 40 largest firms that do not have a presence in ASEAN tend to remain in Australia or to invest in countries with close cultural and historical ties (e.g. the United Kingdom, New Zealand).

On average, major Australian finance MNEs (e.g. Commonwealth Bank of Australia, Australia and New Zealand Banking Group, Westpac Banking Group, Macquarie, QBE Insurance) have a presence in four or more ASEAN Member States. MNEs operating in extractive industries (e.g. BHP Billiton, Woodside Petroleum, Origin Energy, Fortescue Metals, BlueScope Steel) typically have a presence in two or more locations in ASEAN. MNEs in other industries that have established a presence include companies in health care products and services (e.g. Ansell, Blackmores, Cochlear, Healthscope, Primary Health Care and Ramsay Health Care) and information, communication and technology (ICT) activities, including software (e.g. Altium, Atlassian, Computershare, IDP education, Link Administration, Telstra and TPG Telecom).

Some Australian MNEs operate in just one country, using it as a base to conduct business in other Member States. For example, Treasury Wine Estates uses Singapore as a base for coordinating sales to other ASEAN Member States, and Nufarm uses Malaysia as a base to sell into Singapore. Graincorp, a producer of grain and other commodities, maintains a single sales office in Singapore for its exports across ASEAN.

The RCEP offers new opportunities to Australian companies that have not yet established a presence in ASEAN and offers scope for expansion to those that do have a presence, tapping into ASEAN's competitive advantage to serve the world's largest free trade area.

Source: Based on *ASEAN Investment Report 2018.*

(d) Implication of the RCEP for attracting FDI to ASEAN

The RCEP is important for ASEAN. The grouping increases the region's attractiveness for FDI, value chain activities and international production. It provides investors an opportunity to operate in ASEAN and provides access to the world's largest market – more than 2.3 billion people with a combined GDP of $24 trillion. It offers investors opportunities to establish FDI in GVC resilience activities and benefit from regional production networks with different locational advantages, involving ASEAN countries and the other RCEP Member States.

Major provisions of the RCEP Agreement address liberalizing and promoting intra-RCEP trade, investment and services as well as developing e-commerce, which is highly relevant for regional value chains and market-seeking investment (chapter 2).

The economic significance of the RCEP will play a major role in helping ASEAN attract market-seeking and efficiency-seeking investment. The agreement has the potential to provide a boost for FDI and GVC activities with the implementation of liberalization and facilitation measures that can improve efficiency and lower the cost of operating in the region.

ASEAN is a diverse group of countries in terms of development and per capita incomes, economic structure and resource endowments. The diversity of the group is a strength that can boost investment prospects with both locational advantages and catch-up development potential for the least-developed countries (LDCs) (i.e. Cambodia, the Lao People's Democratic Republic and Myanmar). The region offers MNEs investment and production network opportunities within the RCEP, as there is room for investment from RCEP countries in ASEAN to grow. The region also offers MNEs such opportunities from non-RCEP sources, which will remain a major source of investment for ASEAN.

The RCEP could help narrow the development gap between LDCs and other members through investment and industrial connectivity. These LDC members receive much of their FDI from other RCEP members – more than 70 per cent for Cambodia, 80 per cent for Myanmar and 90 per cent for the Lao People's Democratic Republic. These LDC members are expected to benefit as MNEs shift productive capacity from high-cost locations to lower cost environments.

1.5.2. Relocations and GVC resilience

Relocation of production to ASEAN is not new. There have been various waves of relocation by MNEs to ASEAN since the 1970s and 1980s. What is new with the recent wave is the reason: MNEs are relocating not just because of costs but because of a mix of additional considerations related to geoeconomics and supply chain resilience. The diversification of production by MNEs from China to major target destinations such as ASEAN countries was led by rising costs in China. The trade tensions between the United States and China accelerated the process of diversification for some MNEs, including by Chinese companies. The disruption of supply chains by the pandemic further motivated relocation by MNEs to ASEAN.

MNEs from the United States relocated to ASEAN in the 1970s and those from East Asia relocated to ASEAN in the 1980s. In the 1970s, many electronic MNEs from the United States relocated some parts of their production to Malaysia and Singapore for cost reasons. In the 1980s, many companies from Japan and East Asia relocated to ASEAN countries after the Plaza Accord led to the appreciation of their currencies, which made investing cheaper. Increasing costs at home also motivated firms from these economies to relocate to or invest in ASEAN. Since the 2010s, within ASEAN, MNEs have relocated from higher-cost Member States to the CLMV countries. The adoption of regional production networks by MNEs, particularly in the electronics and automotive industries, encouraged the diversification of locations that underpins intrafirm and interfirm transactions exploiting the benefits of the regional division of labour.

Since 2019, the region witnessed another "wave of diversification of operations", accelerated by the trade tensions between the United States and China and supply chains disruption associated with the pandemic. Some MNEs with operations in China relocated their operations or part of their operations out of China; ASEAN Member States were among the target destinations.

Even before the pandemic, some MNEs and many Chinese companies had moved operations to ASEAN because of rising costs in China. In 2019–2020, MNEs moved some operations to ASEAN for various reasons, including to circumvent the United States–China trade tensions (table 1.11). Since 2020, the pandemic has made GVC resilience another reason to invest in ASEAN. The reasons for MNEs moving operations from China to ASEAN have been mixed: primarily rising costs, trade tensions and diversification of supply chains. In some cases, home-country policy measures encouraging diversification of supply chains have also led firms to move operations or reshore out of China (chapter 2).

Table 1.11. Diversification of production from China to ASEAN because of United States–China trade tensions and other reasons, 2019 and 2020 (Selected cases)

Company	Nationality	Industry/activity	Host country	Year	Remarks
Alpan Lighting	United States	Industrial products	Indonesia	2020	Shifting production from China to escape higher tariffs triggered by trade tensions
Dell	United States	Personal computer	Viet Nam	2019	Considered moving up to 30 per cent of production
Delta Electronics	Taiwan Province of China	Electronic components	Thailand	2019	Supplier to Microsoft and Huawei Technologies; moved some production back to home economy and some to Thailand amid the trade tensions
Ever Win International	United States	Electronic components	Philippines	2019	Opened a manufacturing facility in Laguna Technology Park to assist customers with transitioning production outside of China
Foxconn	Taiwan Province of China	Electronic components	Viet Nam	2020	Major supplier of Apple; moved manufacturing of some iPads and Macbooks from China to mitigate the risk of the trade tensions
Harley Davidson	United States	Automotive	Thailand	2019	Finalized location in Thailand
Hasbro	United States	Toy	Viet Nam	2019	Accelerated plans to shift away from China in favour of new plants in Viet Nam and India
HL Corporation Shenzhen	China	Bicycle parts	Viet Nam	2019	Moved production in consideration of trade tensions
HP	United States	Personal computer	Viet Nam	2019	Considered moving up to 30 per cent of production
Hyundai	Korea, Republic of	Automotive	Indonesia	2019	Moved some operations to Indonesia for a mix of reasons, including trade tensions
Irobot	United States	Home and office electronic products	Malaysia	2019	Diversifying manufacturing and supply chain capabilities
Keytronic	United States	Technology hardware	Viet Nam	2019	Added capacity as hedge against uncertainty because of the trade tensions
Kyocera	Japan	Electronic components Printers	Thailand Viet Nam	2019	Relocated part of its automotive camera modules and displays production to avoid impact of the trade tensions Moved production of United States-bound copiers and multifunction printers, mainly to avoid tariffs

Table 1.11. Diversification of production from China to ASEAN because of United States–China trade tensions and other reasons, 2019 and 2020 (Selected cases) (Concluded)

Company	Nationality	Industry/activity	Host country	Year	Remarks
Nintendo	Japan	Consumer electronics	Viet Nam	2019	Began redirecting output of its Switch game player to hedge risks
Parkland	Korea, Republic of	Apparel and textile products	Indonesia	2020	Building a $35 million plant
Prinx Chengshan Shandong Tire	China	Automotive	Thailand	2020	Decided to build a $600 million plant to avoid the impact of the trade tensions
Puma	Germany	Apparel and textile products	Cambodia and Viet Nam	2019	Moved some production from China to other Asian hubs to avoid the trade tensions
Ricoh	Japan	Technology hardware	Thailand	2020	Shifted Chinese production
Samsung	Korea, Republic of	Electronics; mobile phones and computers	Viet Nam	2020	Moved some operations for a mix of reasons, including trade tensions
Sony	Japan	Technology hardware	Thailand	2019	Finalized location
Volex	United Kingdom	Electrical equipment	Indonesia and Viet Nam	2019	Cable manufacturer; shifted some production
Wistron	Taiwan Province of China	Electronic components	Viet Nam	2020	Considered moving half of production capacity outside China as soon as 2021; ramping up operations in Viet Nam
Zhejiang Hailide New Material	China	Apparel and textile products	Viet Nam	2021	Moving to avoid the risks of anti-dumping cases and tariff hikes

Sources: National investment agencies and media reports.
Note: Year = year started production or construction of factory, or year announcement was made.

Some GVC lead firms in electronics value chains persuaded their suppliers to diversify up to 30 per cent of their production out of China, primarily to ASEAN countries. For instance, Apple (United States) persuaded GoerTek (China), a leading AirPods assembler, to move part of its production to Viet Nam in 2019.[6] It has invested $260 million to shift production to Viet Nam.[7] Other Apple suppliers such as Luxshare Precision Industry (China), a supplier of wireless headphones, and Inventec (Taiwan Province of China), an AirPods assembler, have followed suit, relocating part of their production to Viet Nam as well.

Some MNEs have relocated some of their operations from China, Japan and from other economies to Indonesia in 2020.[8] These companies include, from Taiwan Province of China, tyre-maker Kenda Rubber Industrial and Meiloon Industrial for production of audio systems. Japanese companies that have relocated include Sagami Electric for production of electronics components, Panasonic for electronics and Denso for automotive parts. Other MNEs relocating include LG (Republic of Korea) with an electronics production facility, and Aplan Lighting (United States) with a factory for solar light production. Some of these projects could involve expansion of production in Indonesia instead of expanding in China. In 2020, other firms have indicated interest in relocating or diversifying to Indonesia include LG Chemicals (Republic of Korea), which plans to build a $9.8 billion facility including a smelter for an integrated vehicle battery industry.

(a) United States MNEs

Some United States MNEs in China have been reported to have relocated operations to ASEAN and elsewhere.[9] However, a survey by Amcham Shanghai and PwC in 2020 suggested that about 71 per cent of the more than 200 respondents that own or outsource manufacturing operations in China have no plans to leave that host country, and that 14 per cent are moving some production to locations outside the United States.[10] While there are reports highlighting that United States companies in China have relocated or are planning to relocate outside the host country, some provided evidence that United States companies are not moving out en masse. In other words, United States companies are relocating part of their operations to other lower cost neighbouring countries, such as in Southeast Asia.[11]

(b) Japanese MNEs

Some Japanese MNEs have been reported to have diversified their supply chains by moving some production out of China to ASEAN countries, for a mix of reasons. These companies include Denso, Fujikin, Hoya, Panasonic, Sagami Electric and Shin-Etsu.[12] In some cases, the company already had operations in ASEAN and the relocation took the form of constructing plants or ramping up production through expansion. The Government of Japan has also provided support to help Japanese firms strengthen overseas supply chains, including in ASEAN[13] (table 1.12, chapter 2).

Table 1.12. Japan: Approved projects in ASEAN under the Strengthening Overseas Supply Chains programme, as of December 2020 (Selected cases)

Company	Size	Target country	Industry	Proposed products or materials
Able Yamauchi	SME	Viet Nam	Health care	Medical protective clothing; medical protective gowns
Akashi Industry	Large	Indonesia	Automotive	Automobile parts[a]
AMTEC	SME	Thailand	Health care	Disinfectant for hemodialysis machines
Arktech	SME	Philippines	Electronics	Equipment for semiconductor and medical test devices
AVEX	SME	Indonesia	Automotive	Spool valves for continuously variable transmission
Cytex	SME	Philippines	Electronics	Integrated circuit trays
Flex Japan	SME	Indonesia	Health care	Medical protective gowns
Fujifilm	Large	Viet Nam	Health care	Highly sensitive and rapid antigen test kit for SARS-CoV-2
Fujikin	SME	Viet Nam	Electronics	Components for semiconductor manufacturing devices
Gomunolnaki	SME	Indonesia	Electronics	Office automation equipment parts; automotive parts
Hashimoto Cloth	SME	Viet Nam	Health care	Non-woven fabric masks; medical alcohol wet tissues; medical hair caps
Hoya	Large	Viet Nam Lao People's Democratic Republic	Electronics	Components for hard disk drive (glass substrate for storage medium)
Key Technology	SME	Viet Nam	Machine	Construction machinery parts
Kohoku Kogyo	SME	Malaysia	Electrical	Lead terminals for aluminium electrolytic capacitor
Kyosha	Large	Viet Nam	Electrical	Double-sided printed wiring boards

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Table 1.12. Japan: Approved projects in ASEAN under the Strengthening Overseas Supply Chains programme, as of December 2020 (Selected cases) (Concluded)

Company	Size	Target country	Industry	Proposed products or materials
Kyowa Metal Works	SME	Indonesia	Machinery	Synchronizer rings
Mabuchi Motor	Large	Viet Nam	Automotive	Automobile parts (core parts for small motors)
Maruei Industries	SME	Indonesia, Thailand	Automotive	Automobile parts manufacturing[a]
Maruhachi Mawata	SME	Lao People's Democratic Republic	Health care	Medical protective gowns
Matsuoka	Large	Viet Nam	Health care	Personal protective clothing, isolation gowns
Meiko Electronics	Large	Viet Nam	Electronics	Components for smartphones (printed circuit board)
Minamida	SME	Thailand	Automotive	Automobile parts, chassis
MinebeaMitsumi	Large	Thailand	Automotive	Rubber seals for ball bearings
Mitsui Chemical	SME	Viet Nam	Health care	Alcohol disinfectant; chlorine bleach; hand soap
Nadaka/Chikuma Seimitsu Kogyo	SME	Thailand	Automotive	Automobile components (equipment for engines)
Nikkiso	Large	Thailand, Viet Nam	Health care	Blood circuits for artificial dialysis
Nitto Denko	Large	Viet Nam	Health care	N95 mask materials
Panasonic	Large	Viet Nam	Automotive	Automobile relays
PLUS	SME	Viet Nam	Health care	Medical surgical masks
Pronics	SME	Viet Nam	Electrical	Equipment for air conditioners (motor)
RIKI	SME	Thailand	Health care	Medical protective gowns
Rohm	Large	Philippines	Electronics	Thermal printheads
Shin-Etsu Chemical	Large	Viet Nam	Metal and minerals	Rare earth magnets
Showa International	SME	Viet Nam	Health care	Long-sleeved medical gown; cloth masks
Sumida	Large	Viet Nam	Automotive	Transformers for automobile applications
Sumitomo Rubber Industries	Large	Malaysia	Health care	Nitrile rubber gloves
Sumitomo Wiring Systems	Large	Cambodia, Philippines, Viet Nam	Electrical	Wiring harnesses
Taiyo Koko	SME	Malaysia	Metal and minerals	Rare metals
Takeshita Seiyaku	SME	Philippines	Health care	Medical protective gowns
Techno Global	SME	Viet Nam	Health care	Medical face shields
Toda Kogyo	Large	Thailand	Metal and minerals	Bonded neodymium magnets
Toyobo	Large	Malaysia	Health care	Base fabrics for medical products
Yokohama Mold	Large	Thailand	Automotive	Tyre moulds
Yokoisada	SME	Philippines	Health care	Medical surgical masks
Yokowo	Large	Viet Nam	Automotive	Automobile components

Source: JETRO (https://www.jetro.go.jp/services/supplychain/).

Note: In 2020, under the Strengthening Overseas Supply Chains programme of the Government, 343 applications were submitted, and some 80 projects were accepted for support and received financial incentives.

[a] Pilot project.

(c) Korean MNEs

Some Korean MNEs are also diversifying production to ASEAN for a mix of reasons, which include cost factors, tough competition, trade tensions and the impact of the pandemic on supply chains. In some cases, they relocated lower value added activities outside China but still operate higher value added activities in that host country. A major reason for these relocations is to diversify the risk of concentration in China by increasing investment in Southeast Asia or relocating a part of the production out of China. In other cases, Korean MNEs established production facilities in Viet Nam or Indonesia rather than in China.

For instance, in 2020 Samsung closed its last mobile and computer factories in China and moved some operations to Southeast Asian countries.[14] It switched its smartphone production to Viet Nam, where it already has a strong production facility. Samsung Electronics announced plans to shift some part of its display production from China to its plant in Viet Nam.[15] Hyundai Motors set up a task force in 2019 on transportation plans to move facilities from Beijing to Indonesia,[16] which marks the first time that the company relocated overseas production facilities to another country through a massive transportation operation. LG Electronics is also relocating a factory from China to Indonesia.[17]

Supermarket chain operators such as Lotte Mart and E-mart left China because of strong competition and lack of profitability. Instead, these retailers expanded operations in other Southeast Asian countries such as Indonesia and Viet Nam.

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In 2020–2021, MNEs relocated parts of their production from China or announced plans to relocate to ASEAN or other regions for a mix of reasons. Apple, Google and Microsoft (all United States) diversified some production from China to Viet Nam, accelerated by the impact of the pandemic on supply chains.

1.5.3. Infrastructure investment push

Since the pandemic, ASEAN Member States have accelerated the push for investment in infrastructure, facilitated by ambitious national infrastructure plans, policy measures and increased opportunities for private sector participation. Member States are strongly committed to developing and upgrading infrastructure facilities and to making infrastructure development a centre-stage effort to support sustainable post-pandemic recovery. Promotion of private investment and public-private partnerships (PPPs) has also played a role in facilitating infrastructure development, along with growing investment opportunities and bankable projects that have attracted the interest of many MNEs.

Foreign private participation in infrastructure development in ASEAN mostly takes the form of non-equity arrangements such as contracts or concessions, and through project financing, which involves the support of a consortium of banks, including foreign establishments. The role played by foreign MNEs is not confined to investment or engineering-procurement-construction (EPC) projects; they are also involved in providing technology and supplying equipment.

Most Member States plan for an increase in infrastructure spending as part of post-pandemic sustainable recovery measures. For example, the Indonesian Government plans to spend $429 billion on infrastructure in 2020–2024, an increase of 20 per cent from the $359 billion spent in 2015–2019.[18] Some 40 per cent of the investment needed will come from the public sector, with 25 percent from State-owned enterprises and 35 per cent from the private sector; 60 per cent of the investment planned is in the transportation-related segment.[19] The Government established a sovereign wealth fund (SWF) in 2020, with a major focus on infrastructure development in the country. The SWF (Indonesia Investment Authority) is expected to have a fund of $6.5 billion by 2021.[20] Some of the major projects that are being constructed include the $34 billion Trans-Sumatra Toll Road and the $6 billion Jakarta–Bandung high-speed rail link (which is a BRI-related project).

The Government of the Philippines is promoting a $180 billion "build, build, build" programme to upgrade the country's infrastructure facilities.[21] Many of the projects cover development or upgrade of transportation infrastructure such as airports, port terminals, rail link, urban light rail transportation and construction of roads and bridges.[22] Some of the projects include Clark International Airport Expansion Phase 1, the New Clark City Food Processing Terminal and the Subic–Clark Railway Project.

Thailand earmarked $33 billion for PPP projects during 2020–2027, which consist of 92 projects, of which 18 are high-priority infrastructure plans.[23] Six key infrastructure projects in Eastern Economic Corridor are expected to start development in 2020.[24] They include high-speed rail linking three airports (Suvarnabhumi, Don Mueang and U-Tapao), the third phase of Map Ta Phut port, the $1 billion third phase of Laem Chabang port, and the development of Digital Park Thailand. Other major infrastructure includes the $4.5 billion high-speed rail between Bangkok and Rayong, the $1.8 billion KaengKhoi-Map Ta Phut Port double-track railway and the $580 million Pattaya–Map Ta Phut motorway.

In Viet Nam the infrastructure investment need has been estimated at $24 billion annually between 2016 and 2040.[25] Most of the need is projected to be in transportation and electricity. Major transportation project plans include an estimated $50 billion high-speed north–south rail link, $13 billion for eight metro lines each in Hanoi and in Ho Chi Minh City, $14 billion for the North-South Expressway, and $20 billion to build new seaports and upgrade existing ones.[26] In 2020, Viet Nam adopted a new PPP law, which aims to facilitate private investment in infrastructure (chapter 2).

The infrastructure investment need in the region is huge, estimated between $110 billion and $184 billion annually during 2015–2030 *(AIR 2015*, ADB 2017). This need covers transport, power and telecommunication. The private sector is playing an important role in infrastructure development through PPPs. MNEs and foreign investors have been contributing to infrastructure development in the region through various channels, including investing or sponsoring, financing, providing EPC capacity and technology, and supplying equipment.

The region has been receiving attention from global infrastructure MNEs in the construction of infrastructure for telecommunication (5G networks, see chapter 3), transport (e.g. rail) and power. Many of the power projects are related to renewable sources, including hydropower and wind farms, reflecting the growing trend towards sustainable types of power generation.

Asian infrastructure MNEs are active investors and EPC contractors. Most are from China, Japan, the Republic of Korea and ASEAN (table 1.13). Since the introduction of the BRI in 2013, Chinese companies have been active in a wide range of infrastructure development projects in the region, from rail to telecommunication to power (see section 1.5.4). The $5.4 billion Udenna–China Telecom project in the Philippines, the $1.3 billion Sihanoukville power plant in Cambodia and the $1.1 billion Indonesia Stainless Steel Integrated Smelting are all BRI-related projects.

Power development is a major segment of project finance activities in ASEAN. The cost of some recent power projects exceeds $1 billion. In 2021, GS Energy (Republic of Korea), with a local partner in Viet Nam, achieved financial closure to construct LNG power plants worth $3 billion, and a consortium led by Posco Engineering & Construction (Republic of Korea) and Mitsubishi Corporation (Japan) achieved financial closure for the $840 million Pulau Indah Power Plant in Malaysia. Some Member States are inviting private participation in national infrastructure development projects (box 1.3). Large transportation and telecommunication infrastructure projects are at different stages of development in the region. These mega-projects involve MNEs as financial sponsors or EPC providers, including a consortium of foreign banks providing debt financing. Examples include the $6 billion Laos–China Railway link and the $6 billion Jakarta–Bandung High-speed Rail project, both of which are being developed by the China Railway Group consortium.

Table 1.13. Project finance examples in infrastructure-related activities in ASEAN, 2019 and 2020 (Selected cases)

Project	Country	Project cost ($ million)	Industry	Ultimate sponsors	Ultimate sponsor headquarters economy	Year announced
Laos–China Railway	Lao People's Democratic Republic	6 000	Transportation	China Railway Group consortium	China	Ongoing
Jakarta–Bandung High-speed Rail	Indonesia	6 000	Transportation	China Railway Group consortium	China	Ongoing
Udenna–China Telecom[a]	Philippines	5 400	Telecommunication	China Telecommunications Udenna	China Philippines	2019
Peranap dimethyether (DME) plant	Indonesia	2 991	Power	Tambang Batubara Bukit Asam Air Products & Chemicals	Indonesia United States	2019
Van Phong 1 coal-fired power plant	Viet Nam	2 675	Power	Sumitomo	Japan	2019[b]
Kanbauk LNG-fired power plant	Myanmar	2 099	Telecommunication	Total Siemens	France Germany	2019
PTTEP-GPSC gas-fired power plant	Myanmar	1 999	Power	Global Power Synergy PTT	Thailand Thailand	2019
Rayong gas-fired power plant	Thailand	1 656	Power	Gulf Energy Development Mitsui	Thailand Japan	2019
Gulf PD natural gas-fired combined-cycle power plant	Thailand	1 653	Power	Gulf Energy Development Mitsui	Thailand Japan	2019[a]
Sihanoukville coal-fired power plant[a]	Cambodia	1 300	Power	Cambodia International Investment Development Group China	Cambodia China	2019
Gresik container port	Indonesia	1 206	Transportation	PT Maspion Dubai World	Indonesia United Arab Emirates	2019
Indonesia Stainless Steel Integrated Smelting[a]	Indonesia	1 054	Smelter	Jiangsu Delong Nickel Industry Xiamen Xiangyu Group	China China	2019
Cavite–Laguna Expressway	Philippines	1 046	Transportation	Metro Pacific Investments	Hong Kong, China	2019[a]
Hanjo Bataan thermal power plant	Philippines	1 000	Renewable power	Hanjo Group	Korea, Republic of	2019
Ahlone gas-fired combined-cycle power station expansion	Myanmar	600	Power	TTCL Chugoku Electric Power Shikoku Electric Power	Thailand Japan Japan	2019
Cebu–Cordova Link Expressway	Philippines	573	Transportation	Metro Pacific Investments	Hong Kong, China	2019[b]
Kaliwa intake weir	Philippines	410	Water and sewerage	Global Utility Development	Japan	2019
Upper Stung Tatay 275 MW hydropower plant[a]	Cambodia	396	Renewable power	China National Machine Industry China National Machine Industry Chint Group	China China China	2019
Airtrunk hyperscale data centre	Singapore	331	Telecommunication	TPG Capital Goldman Sachs	United States United States	2019
Loyang data centre facility (Project Solo)	Singapore	326	Telecommunication	Airtrunk Founders TPG Capital Goldman Sachs	Singapore United States United States	2019
Riau gas power plant	Indonesia	290	Power	Medco Energi International Ratchaburi Electricity Generating Holding	Indonesia Thailand	2019[b]
Weda Bay power plant[a]	Indonesia	120	Renewable power	PT Daya Listrindo Utama Tsingshan Holding Group	Indonesia China	2019

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Table 1.13. Project finance examples in infrastructure-related activities in ASEAN, 2019 and 2020 (Selected cases) (Concluded)

Project	Country	Project cost ($ million)	Industry	Ultimate sponsors	Ultimate sponsor headquarters economy	Year announced
Clark International Airport operations and maintenance	Philippines	115	Transportation	Changi Airports JG Summit Holdings Filinvest Development	Singapore Philippines Philippines	2019[a]
La Gan offshore wind power projects	Viet Nam	10 000	Renewable power	Asiapetro Copenhagen Infrastructure Novasia Energy	Viet Nam Denmark Viet Nam	2020
ExxonMobil gas-to-power plant	Viet Nam	5 090	Power	ExxonMobil	United States	2020
Quang Tri coal-fired power plant	Viet Nam	2 400	Power	EGAT EGAT Electricity Generating	Thailand Thailand Thailand	2020
Phou Ngoy 728 MW hydropower plant	Lao People's Democratic Republic	2 400	Renewable power	Doosan Korea Western Power consortium	Korea, Republic of Korea, Republic of	2020[b]
Sanakham power plant	Lao People's Democratic Republic	2 100	Power	Datang International Power consortium	China	2020[b]
Dakcheung Clean coal power plant	Lao People's Democratic Republic	1 700	Power	KMX Evolution Power Invest	Lao People's Democratic Republic Singapore	2020
BCPG and Impact Electrons wind farm	Lao People's Democratic Republic	840	Renewable power	Bangchak Impact Electrons Siam	Thailand Thailand	2020
Pulau Indah combined-cycle gas turbine power plant	Malaysia	752	Power	Korea Electric Power Worldwide Holdings Tadmax Resources	Korea, Republic of Malaysia Malaysia	2020
Batangas Clean Energy	Philippines	741	Power	Gen-X Energy Group LCT Energy & Resources	United States Philippines	2020
Maung hydropower plant	Indonesia	650	Renewable power	KEPCO	Korea, Republic of	2020
Aceh 400 MW power plant	Indonesia	600	Power	China Datang Overseas Investment PP Energy Sumberdaya Sewatama	China Indonesia Indonesia	2020[b]
Loc Ninh solar power plant[a]	Viet Nam	384	Renewable power	Super Energy	Thailand	2020
Tay Ninh solar projects	Viet Nam	300	Renewable power	B.Grimm Power	Thailand	2020
MRT Jakarta extension project	Indonesia	287	Transportation	Adhi Karya Shimizu	Indonesia Japan	2020
Hanoi City 75 MW waste-to-energy power project[a]	Viet Nam	195	Renewable power	China Tian Ying	China	2020
Phu Yen solar farm	Viet Nam	186	Renewable power	B.Grimm Group Truong Thanh Vietnam Group	Thailand Viet Nam	2020
Hongshi Cement Wharf project[a]	Indonesia	150	Transportation	Hongshi Holding Group	China	2020
Rayong co-generation power plant	Thailand	140	Renewable power	Denham Capital Management Nexif Energy RATCH Group	United States Singapore Thailand	2020[a]

Sources: UNCTAD, Project Finance database and World Bank PPI database.
[a] Refers to BRI-related projects.
[b] Date of financial closure.

Box 1.3. Indonesia: Public-private partnership infrastructure projects plan

Indonesia is accelerating infrastructure development as a measure for post-pandemic recovery. It is promoting PPP in the development of infrastructure projects through projects listed in the country's national infrastructure plan (box table 1.3.1).

Box table 1.3.1. PPP infrastructure projects called for by Indonesia, 2020 (Selected cases) (Millions of dollars)

	Estimated project cost ($ million)
Project Ready	
Gedebage–Tasikmalaya–Cilacap Toll Road[a]	4 143
Cikunir–Karawaci Inner City Elevated Toll Road	1 816
Cikunir–Ulujami Jakarta Outer Ring Road Elevated Toll Road[a]	1 541
Kamal–Teluk Naga–Rajeg Toll Road	1 331
Semanan–Balaraja Toll Road	1 117
South Sentul–West Karawang Toll Road	1 068
Semarang Harbour Toll Road	837
Bogor–Serpong (via Parung) Toll Road	622
Patimban Port[a]	511
Patimban Access Toll Road[a]	457
Multi Lane Free Flow Toll Road Transaction System[a]	301
Sarbagikung Regional Water Supply System[b]	222
Under preparation	
Semarang City Light Rail Transit[c]	1 041
Makassar–Maros–Sungguminasa–Takalar Toll Road	638
Batam–Bintan Bridge	610
Construction of Merangin Dam (Option 2A)	331
Construction of Singkawang Airport	313
Development of Anggrek Port[a]	70
Development of Baubau Port	24

Source: National Development Planning Agency (public-private partnership infrastructure projects planned in Indonesia in 2020).
[a] Already tendered as of June 2021.
[b] Moved to under preparation as of June 2021.
[c] Dropped from the list as of June 2021.

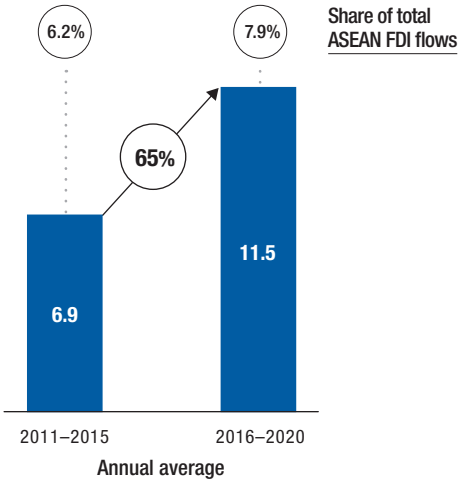
1.5.4. Growth of Chinese FDI and MNE activities

ASEAN has seen robust investment from China in the last decade through equity investment (i.e. FDI) and non-equity modes (e.g. international infrastructure projects). In some Member States (e.g. Cambodia and the Lao People's Democratic Republic), FDI from China constituted the largest source of investment for consecutive years. Chinese MNEs have been actively investing in many industries, from real estate and manufacturing to services such as finance, wholesale and retail trade, e-commerce and the digital economy. In 2019, there were 5,600 Chinese FDI enterprises in ASEAN.

FDI from China has risen by 65 per cent over the past decade, from an annual average of $6.9 billion in 2011–2015 to $11.5 billion in 2016–2020, pushing up China's share in total FDI in ASEAN from 6.2 per cent to 7.9 per cent in the period (figure 1.12). Despite the rise, ASEAN accounts for only 5 per cent of China global OFDI stock in 2019, up from 4.5 per cent

in 2010 (table 1.14). But increasing Chinese investment to ASEAN has pushed the region's share of global OFDI flows from China from an average of 5.5 per cent in 2009–2010 to 9.0 per cent in 2018–2019.

Figure 1.12. China FDI flows in ASEAN, annual averages, 2011–2015 and 2016–2020
(Billions of dollars and per cent)



Source: ASEAN Secretariat, ASEAN FDI database.

Table 1.14. China OFDI flows and stock in ASEAN (Billions of dollars)

	OFDI flows				OFDI stock	
Destination	**2009**	**2010**	**2018**	**2019**	**2010**	**2019**
China, global OFDI	57	69	143	137	317	2 199
ASEAN	2.6	4.4	12.5	13.0	14.3	109.8
Brunei Darussalam	0.01	0.02	-0.01	-0.01	0.04	0.4
Cambodia	0.2	0.5	0.8	0.7	1.1	6.5
Indonesia	0.2	0.2	1.9	2.2	1.1	15.1
Lao People's Democratic Republic	0.2	0.3	1.2	1.1	0.8	8.2
Malaysia	0.05	0.2	1.7	1.1	0.7	7.9
Myanmar	0.4	0.9	-0.2	-0.04	1.9	4.1
Philippines	0.04	0.2	0.06	-0.01	0.4	0.7
Singapore	1.4	1.1	6.4	4.8	6.1	52.6
Thailand	0.05	0.7	0.7	1.4	1.1	7.2
Viet Nam	0.1	0.3	1.1	1.6	1.0	7.1
ASEAN share of China global OFDI (%)	5	6	8.7	9.4	4.5	5.0

Source: Ministry of Commerce, Statistical Bulletin of China's Outward Foreign Direct Investment (various years).
Note: Numbers rounded.

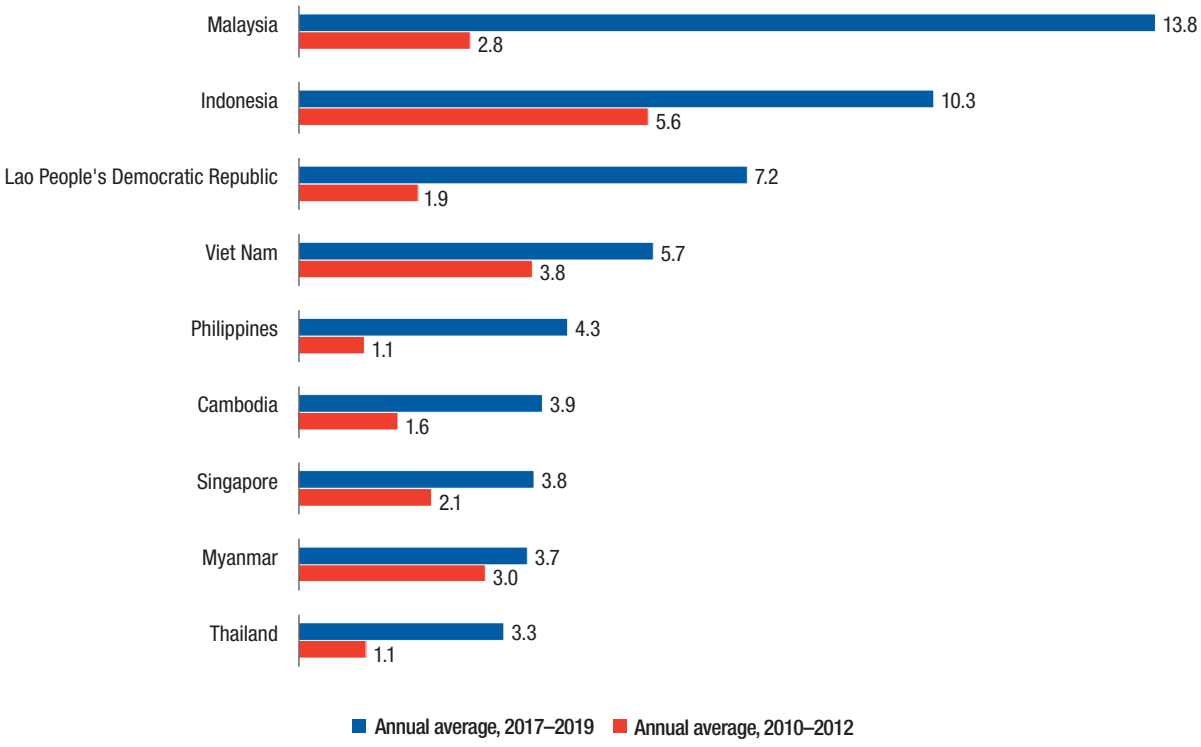
In 2019 nearly $180 billion of China OFDI stock (8.2 per cent of its total OFDI stock) was in countries along the BRI. The top 10 BRI destinations were Singapore, Indonesia, the Russian Federation, the Lao People's Democratic Republic, Malaysia, the United Arab Emirates, Kazakhstan, Thailand, Viet Nam and Cambodia, in that order. ASEAN accounted for more than 60 per cent of the stock in the BRI route.

(a) International project contracts

An important feature in the internationalization of Chinese MNEs is their involvement with international infrastructure contracts. Many are participating in the development of infrastructure across the region. They are building projects in transportation (high-speed rail) and energy (power plants), involving many State-owned enterprises.

Chinese MNEs are increasing their activity in non-equity forms of participation in infrastructure and construction projects in ASEAN (figure 1.13). These projects involve contractual arrangements through various types of concession awards such as build-operate-transfer and build-operate-own.

Figure 1.13. ASEAN: International contracting projects from China, annual averages, 2010–2012 and 2017–2019 (Billions of dollars)



Source: China Business Yearbook (various years) and Annual Report on China International Project Contracting (various years).
Note: Data for 2010–2012 from China Business Yearbook and for 2017–2019 from Annual Report on China International Project Contracting.

Asia is the largest destination for Chinese international contracts, accounting for 53 per cent, an annual average of $256 billion in new global projects during 2017–2019 (table 1.15). Within Asia, ASEAN is the largest target destination. In this period, some 22 per cent of Chinese international contracts were in ASEAN, underscoring the importance of the region for the participation of Chinese MNEs in infrastructure development. Most contracts were in transportation, power and telecommunication, and many are also identified as BRI-related projects (table 1.16).

Table 1.15. International contracting projects by Chinese companies, value by destination, annual averages, 2010–2012 and 2017–2019

	Value, annual average ($ billion)	
Destination region/subregion	**2010–2012**	**2017–2019**
World	144	256
Asia	69	135
East Asia (excluding China)	8	15
South Asia	15	27
South-East Asia	23	57
West Asia	17	30
Central Asia	5	6

Source: China Business Yearbook (various years) and Annual Report on China International Project Contracting (various years).

Table 1.16. Major BRI-related projects by Chinese companies in ASEAN, by value, 2019–2021 (Selected cases)

Year	Project	Location	Activity	Participating MNE	Value ($ billion)
2020	East Coast Rail Link (restart)	Malaysia	Transportation	China Harbour Engineering	10.7
2019	Tilowa Shipyard, phase III	Myanmar	Construction	China National Engineering	2.1
2019	Phnom Penh-Sihanoukville Expressway	Cambodia	Transportation	China Road & Bridge Corporation	2.0
2020	Data Dian, 1,200 MW hydropower station, phase I	Indonesia	Power	China Gezhouba (Group)	1.6
2020	China–Thailand Railway Cooperation Project, phase I (Bangkok–Nakhon Ratchasima section)	Thailand	Transportation	China State Construction Engineering	1.6
2019	Construction of 30,000 affordable housing units in Rongguoer New City, West Java Province	Indonesia	Construction	China Civil Engineering Group	1.6
2019	Kayang A hydropower plant	Indonesia	Power	China Gezhouba (Group)	1.4
2020	Makati subway system	Philippines	Transportation	China State Construction Engineering	1.2
2020	Tuas integrated waste treatment facility, phase I (first tender section)	Singapore	Construction	China Harbour Engineering	1.1
2019	Vientiane–Vang Vieng Expressway	Lao People's Democratic Republic	Transportation	Yunnan Construction Investment Holding Group	1.1
2021	Subic–Clark Railway	Philippines	Transportation	China Harbour Engineering	0.9
2019	Pasay reclamation project, Manila Bay	Philippines	Construction	China Harbour Engineering	0.7
2020	Camou No. 1,350 MW wind power project	Viet Nam	Power	China Gezhouba (Group)	0.7
2020	Shoc Trang No. 4,350 MW wind power project	Viet Nam	Power	China Gezhouba (Group)	0.7
2019	"The Sail" Complex construction, Malacca	Malaysia	Construction	Power Construction Corporation of China	0.6

/...

Table 1.16. Major BRI-related projects by Chinese companies in ASEAN, by value, 2019–2021 (Selected cases) (Concluded)

Year	Project	Location	Activity	Participating MNE	Value ($ billion)
2020	Phnom Penh International Airport, new terminal	Cambodia	Construction	China State Construction Engineering	0.6
2019	Tuas Port	Singapore	Transportation	Shanghai Zhenhua Heavy Industries	0.5
2020	Khon Kaen solar thermal photovoltaic hybrid power station (EPC)	Thailand	Power	China Gezhouba (Group)	0.5
2019	New Mandalay Resort City	Myanmar	Construction	China Railway Group	0.5
2020	International Financial Center, Manila, phase I	Philippines	Construction	China State Construction Engineering	0.4
2020	Landmark Tower engineering contract	Indonesia	Construction	China State Construction Engineering	0.4
2019	Jurong Regional Line J102	Singapore	Transportation	Shanghai Tunnel Engineering	0.4
2021	CRL1 Subway	Singapore	Transportation	China State Construction Engineering	0.4
2020	Lộc Ninh, 550 MW photovoltaic project	Viet Nam	Power	Power Construction Corporation of China	0.4
2020	Bạc Liêu, 141 MW offshore wind power project (EPC), phase III	Viet Nam	Power	Power Construction Corporation of China	0.3
Memorandum					
2015	Jakarta–Bandung High-speed Rail	Indonesia	Transportation	China Railway International	6.1
2015	Boten–Vientiane Railway	Lao People's Democratic Republic	Transportation	China Railway International	6.0
2017	Jakarta–Bandung High-speed Railway	Indonesia	Transportation	China Railway International	4.7
2016	Gemas–Johor Bahru Dual-track Electrified Railway	Malaysia	Transportation	Consortium of China Railway Construction Corporation, China Railway Engineering Corporation, China Communications Construction	2.2
2016	Malaysia Southern Railway	Malaysia	Transportation	China Communications Construction	2.1
Total value					**32.3**

Sources: Annual Report on China International Project Contracting 2019, company annual reports and media.
Note: EPC = engineering, procurement and construction.

1.5.5. FDI in the digital economy and Industry 4.0

Investment in the digital economy and in activities related to Industry 4.0 is rising in ASEAN. This is because of the rapid growth of the digital economy (*AIR 2019*) and increasing investment opportunities in Industry 4.0 related sectors as well as commitments of ASEAN Member States towards Industry 4.0 transformation. Member States are also pushing forward with digital infrastructure development such as in 5G networks. Some are actively attracting FDI in data centres and cloud facilities to improve digital ecosystems. These digital developments are attracting growing attention by MNEs to invest and strengthen their presence in the region. The rise of investment and MNE activities in the digital economy is discussed in *AIR 2019* and recent trends in Industry 4.0 are discussed in chapters 3 and 4 of this report.

1.6. PROSPECTS AND CONCLUSION

The outlook for FDI in ASEAN in 2021 is promising because of improving national and global economic growth and strong efforts by the Member States to attract FDI. Many Member States reported an increase in FDI in the first quarter of 2021 as compared with the last quarter of 2020. UNCTAD has projected an increase in FDI flows to Asia in 2021 of between 5 and 10 per cent (*WIR 2021)*. Given ASEAN's significance as a major destination for FDI, that projection reflects closely the region's ability to attract FDI next year. However, much will depend on how well countries in the region are able to contain the new wave of the pandemic unfolding in 2021.

A number of key developments will help the region turn around. First, Member States continued to implement economic stimulus packages to bolster resilience and have adopted measures favourable to FDI, including implementation of the ASEAN Comprehensive Recovery Framework. Second, during the pandemic some industries strove to increase activities in the online domain, in e-commerce and the digital economy. These industries will continue to attract investor interest. ASEAN Member States continued to push for digital infrastructure development (5G networks and data centres) and private investment in these areas, including cloud computing. FDI in these areas is expected to remain robust. The region is projected to become a rapidly growing global data centre hub in the next five years, overtaking the growth in North America and in Asia-Pacific countries outside ASEAN.[27] Many data centre and cloud MNEs are increasing their investment or building more facilities, driven by a rapidly growing digital economy and the region's push for Industry 4.0 transformation. Some industries will continue to be affected, particularly those in hospitality, tourism and manufacturing. However, some Member States will fare better because they already recorded a sharp fall in investment, in particular in manufacturing, and because of their country-specific circumstances (e.g. those that are attractive locations for manufacturing activities and targets for MNE's efforts to diversify their supply chains).

Member States are also accelerating the development of major physical infrastructure (e.g. transportation, telecommunication, power and special economic zones (SEZs)) and actively promoting private sector participation, including FDI. For example, Indonesia is accelerating the development of SEZs and other infrastructure, including facilitating investment in priority industries.[28] Other Member States such as Malaysia, the Philippines, Thailand and Viet Nam are also pushing for major infrastructure development projects, which open up investment opportunities.

The signing of the RCEP Agreement will bolster the region's ability to attract FDI for post-pandemic recovery[29] Relocation of production by Chinese firms and other MNEs for cost reasons and to circumvent the impact of the United States–China trade tensions, as well as to build a more resilient supply chain network, will continue to benefit the ASEAN Member States in 2021 and beyond. Home-country measures such as Japan's programme to diversify supply chains will help the region become host to more factories and business services.

NOTES

[1] *Xinhuanet*, "Spotlight: Brunei-China joint venture to invest 13.654 bln USD on petrochemical expansion", 17 September 2020.

[2] Department of Statistics, Malaysia, "Malaysia: FDI & DIA statistics", *Quarterly Bulletin* (various quarters), 2020.

[3] *Manila Bulletin,* "FDI down 24.6% in 2020 – BSP", 10 March 2021 and *Rappler,* "Foreign direct investments down 24.6% in 2020 due to pandemic", 10 March 2021.

[4] See *WIR 2021* for definition of international project finance.

[5] Foreign MNEs often establish regional headquarters and holding companies in some ASEAN Member States, particularly Singapore, to oversee their investment and operation activities in the region. This type of conduit investment inflates the share of intra-ASEAN investment. UNCTAD presents a new methodology to compute intraregional investment between ultimate owners and final destinations within regions (i.e. netting out the inflating effect of regional conduit investment) (*WIR 2021,* section I.D)

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[7] *ASEAN Today,* "Unfulfilled potential: Trade war has a boon for Vietnam, but opportunities have been missed", 11 December 2019

[8] BKPM press release, "President: "I'm pleased 7 companies have confirmed relocation"", June 2020 and *Reuters,* "Indonesia reports $850 million in factory investments, says billions committed", 30 June 2020.

[9] *Forbes,* "New data shows US companies are definitely leaving China", 7 April 2020 and AmCham Shanghai and AmCham China 2019 survey, Joint press release, 22 May 2019 (https://www.amcham-shanghai.org/sites/default/files/2019-05/Joint_survey_on_tariffs_May_2019.pdf)

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[18] *Infrastructure Investor,* "Indonesia plans $430 infrastructure spend by 2024", 23 July 2020.

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[24] *Thailand Business News,* "Thailand must start six EEC infrastructure projects this year", 7 January 2020.

[25] Global Infrastructure Hub, "Viet Nam: country profile" (https://s3-ap-southeast-2.amazonaws.com/global-infrastructure-outlook/countrypages/GIH_Outlook+Flyer_Vietnam.pdf).

[26] Department for International Trade, "Vietnam infrastructure", May 2019.

[27] See Cushman and Wakefield (2019).

[28] Ministry of Finance, Indonesia, KKSK PEN Briefing, February 2021, https://www.kemenkeu.go.id.

[29] UNCTAD, GITM37 Special edition, "RCEP Agreement a potential boost for investment in sustainable post-COVID recovery", November 2020 (https://unctad.org/system/files/official-document/diaeiainf2020d5_en_0.pdf).

CHAPTER 2

FDI policy environment in ASEAN

2.1. INTRODUCTION

Over the years, ASEAN Member States have adopted many significant regional agreements and national measures that have important implications for FDI, mostly favouring it. These agreements and measures, together with the influence of regional integration, have since 2017 led to consecutive years of high FDI inflows, exceeding $145 billion. In 2020, however, the pandemic halted the strong inflows and upward FDI trend. In supporting businesses affected by the pandemic and in attracting and retaining investment, ASEAN Member States adopted more regional agreements and national measures favourable to investment.

This chapter provides an analysis of the FDI policy environment in ASEAN in 2018–2020. It asserts a close link between policy development and the increasing attractiveness of the region for FDI and international production activities. The chapter analyses investment measures adopted at the regional and national levels, in two groups of categories: (i) liberalization, facilitation and promotion, and (ii) regulation and restriction. Other agreements or measures adopted at the regional or national level may also affect the FDI environment; however, this report analyses only agreements, laws and measures that relate to FDI. The major policy areas covered include the following:

(i) FDI-related policy measures and agreements at the regional and national levels

(ii) Pandemic-related measures

(iii) Measures to attract FDI relocation and strengthen GVC resilience

(iv) The Regional Comprehensive Economic Partnership (RCEP) Agreement and provisions relating to FDI

2.2. SUMMARY OF POLICY MEASURES

The FDI policy environment in ASEAN improved further in 2018–2020 as more favourable investment measures were adopted by the Member States. At the regional level, Member States continued to implement measures and work programmes to realize the goals of the ASEAN Economic Community (AEC), signed an ASEAN Agreement on Electronic Commerce in 2019, and in 2020 upgraded the ASEAN Comprehensive Investment Agreement (ACIA) and signed a new ASEAN Trade in Services Agreement (ATISA). The ASEAN Comprehensive Recovery Framework adopted in 2020 guides post-pandemic recovery efforts with coordinated

actions focusing on key sectors, including to attract FDI. An ASEAN Investment Facilitation Framework, in development, is expected to be adopted in 2021. It will contain non-legally binding guiding principles and actions to (i) improve accessibility, transparency of investment rules, regulations and procedures; (ii) streamline and expedite administrative procedures and requirements for entry, retention and expansion of investment; and (iii) create favourable conditions for investment and for doing business in the region.

Other regional agreements or initiatives (e.g. infrastructure connectivity and customs integration) that have important implications for the investment environment and for reducing transaction costs also were adopted and implemented in the period under review. ASEAN Member States are working together on regional initiatives such as digital integration, the ASEAN Digital Masterplan 2025 and industrial transformation to Industry 4.0 – all of which will help improve investment opportunities, efficiency and digital connectivity in the region.

The region remains committed to promoting FDI by implementing the various regional agreements. Under the ACIA, for example, Malaysia has further liberalized some industries that previously were closed to foreign investment (e.g. steel bars and wire rods) by phasing them into the ACIA inclusion list, and the Philippines removed registration requirements for loans related to foreign exchange business.

Customs integration was further strengthened in September 2020 with the introduction of an ASEAN-wide Self-Certification system to facilitate intraregional trade. The system simplifies customs procedures by allowing exporters to self-certify the origin of their exports to benefit from preferential tariffs under the ATIGA. An ASEAN Customs Transit System – an online transit management system to facilitate cross-border land transportation of goods between Member States – was launched in November 2020. Live exchange of the ATIGA electronic Form D (ATIGA e-Form D) began in December 2019. The e-Form D through the ASEAN Single Window arrangement is expected to facilitate intraregional trade, reduce costs and support regional production networks.

Under ASEAN-plus-one economic relations, Member States have signed free trade agreements (FTAs) and protocols to further strengthen agreements with partner economies. For instance, in 2019 an agreement to amend the ASEAN–Japan Comprehensive Economic Partnership Agreement was signed and in June that year the ASEAN–Hong Kong, China SAR Investment Agreement entered into force. The region is also making progress towards upgrading bilateral FTAs containing investment chapters with other partner countries. These agreements include the ASEAN–Australia–New Zealand FTA, the ASEAN–China Investment Agreement and preparations for the launch of the ASEAN–Canada FTA.

A major development in extraregional FTAs was the signing of the RCEP Agreement on 15 November 2020, which involved all ASEAN Member States plus Australia, China, Japan, the Republic of Korea and New Zealand. The agreement establishes the world's largest economic bloc and is expected to have significant implications for FDI in ASEAN (chapter 1). The Agreement contains a chapter on investment and other provisions that also relate to FDI (e.g. coverage of services, e-commerce, rules of origin, customs and other trade facilitation measures).

On investment, it aims to create an enabling environment by providing investment protection, liberalization, promotion and facilitation. These provisions upgrade and enhance the existing ASEAN-plus-one FTAs. The investment chapter includes the following key elements:

(i) Most-favoured-nation treatment and commitments to the prohibition of performance requirements that go beyond the WTO Trade-Related Investment Measures Agreement

(ii) National treatment, fair and equitable treatment, direct and indirect expropriation clauses, and free transfer of funds

(iii) Schedule of reservations and non-conforming measures using the negative-list approach

(iv) Investment promotion and facilitation provisions, which address simplification of investment approval procedures, investment assistance, and provision of advisory services and information

The chapter does not introduce investor–State dispute settlement (ISDS). However, parties are to enter into discussions on ISDS no later than two years after the date of entry into force of the agreement and conclude them within three years of the commencement of the discussions.

At the national level, ASEAN Member States adopted many national laws and measures that improve the investment environment. Few measures were restrictive or entailed regulations limiting FDI. Some Member States further liberalized their national investment regimes. Actions taken included further opening up industries for investment, relaxing limitations on foreign equity ownership, relaxing investment restrictions or conditions, and deregulating or undertaking regulatory reforms to improve the investment environment. They have granted new investment incentives, further streamlined investment procedures and provided more facilitation measures and institutional support.

Most measures adopted in the period under review related to investment promotion and facilitation. They cover measures that aim at improving the ease of doing business, reducing transaction costs, simplifying investment procedures, institutionalizing online facilities and providing investment incentives, offering further assistance to investors (including aftercare services) and enhancing one-stop centre facilities.

The economic impact of the pandemic affected FDI inflows in 2020. Investment into the region fell by 25 per cent from the peak of $182 billion in 2019. Countries were quick to respond with measures to mitigate the impact of the pandemic on FDI. They introduced economic stimulus packages and implemented measures to attract and support investment. Attracting FDI is widely seen as an important course of action for sustainable recovery, given that FDI has long-term development impacts.

The pandemic-related FDI measures adopted included e-application systems, fiscal stimulus packages, financial incentives and assistance, tax discounts, further streamlining of investment procedures and application processes, extensions of deadlines for administrative compliance (e.g. tax returns and extension of incentives deadline) and other services extended to investors. Investment promotion agencies (IPAs) in the region kept offices open for investment applications and assisted investors with extended online services.

Table 2.1 summarizes key clusters of pandemic-related FDI measures introduced by Member States, and table 2.2 highlights specific measures, mostly related to investment promotion and facilitation.

Table 2.1. ASEAN: Investment policy measures in response to the pandemic

Investment policy area	Policy measures (examples)
Investment facilitation	• Alleviation of administrative burdens and bureaucratic obstacles for firms • Negotiation for a non-legally binding ASEAN Investment Facilitation Framework expected for adoption in 2021
Investment retention and aftercare measures	• COVID-19-related information services • Administrative and operational support during the crisis • Extension of payment period for fees, taxes, duties and utilities • Extension of deadlines for filing tax returns • Wage subsidies and waivers of worker levies
Investment incentives	• Financial or fiscal incentives to produce COVID-19-related medical goods • Incentives to enhance contracted economic activities • Economic stimulus packages and assistance to reduce business costs
Local small and medium enterprises (SMEs) and supply chains	• Financial or fiscal support for domestic suppliers (such as SMEs) • Regional cooperation on opening markets and supporting the smooth flow of goods and supply chains
National security and public health	• Facilitate or simplify FDI application in COVID-19-relevant industries • Promotion of FDI in the health care sector
Other State intervention in the health industry	• Export restrictions or regulatory requirements (initial period) • Import facilitation • Accelerated customs clearance
Intellectual property (IP)	• General authorization of non-voluntary licensing to speed up research and development (R&D) • Non-voluntary licensing specific to IP holder, to enable imports of medication

Source: Adapted from UNCTAD (2020).

Member States were also actively promoting FDI in health care. In the face of the pandemic, they quickly put in place measures such as additional incentives, duties exemption and import facilitation to relieve supply chain bottlenecks and to encourage the production of medical supplies such as personal protective equipment (PPE) and medical devices. While Member States supported the production and import of health care products, they imposed temporary restrictions on exports of these products (in the initial phase of the pandemic), which had implications for the export-oriented health care industry. In some cases, export of health care products was not restricted but exporters were required to obtain approval from relevant authorities. In addition to national measures, Member States cooperated regionally on pandemic-response measures, which included supporting the smooth flow of supply chains and not imposing export bans on essential goods (section 2.4).

Table 2.2. ASEAN: Pandeminc-related FDI measures, 2020

Measures	Brunei Darussalam	Cambodia	Indonesia	Lao People's Democratic Republic	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Temporary restrictive measures on FDI	No	No	No	No	No	No	No	No	No	No
Relaxed measures on FDI	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
of which:										
Liberalization										
Relax investment conditions/licensing requirements			✓					M&As	✓	
Facilitation										
Simplify investment process			✓		✓	✓	✓			
Accelerate investment approval/ licenses			✓		✓	✓	✓		✓	
Offer online application and services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grant investment incentives	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Extend compliance deadlines		✓	✓	✓	✓			✓	✓	✓
Offer taxation/duties reduction or exemption	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Offer utility and administrative fees reduction/exemption	✓			✓	✓	✓				✓
Implement wages subsidy/worker levy		✓						✓		
Promotion										
Maintain/extend IPA services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Offer publications/seminars			✓		✓				✓	
Pursue matchmaking/business linkages			✓				✓			
Provide special assistance services to investors			✓		✓	✓	✓		✓	
Promote investment in medical sector			✓		✓	✓	✓	✓	✓	✓

Sources: ASEAN Secretariat and annex table 2.3.

In 2018–2020, some MNEs relocated production to the region because of increasing costs at home, to circumvent the impact of the United States–China trade tensions and to build a more resilient supply chain network (chapter 1). ASEAN Member States are among the major beneficiaries of this recent investment diversification trend. Some ASEAN Member States also introduced specific measures to attract factory relocations. These measures cover actions to help investors relocate quickly and facilitate investment by establishing one-stop facilities for obtaining business licenses, targeting investment, providing special investment incentives for a specific period, and setting up a special task force to facilitate such FDI.

As of April 2021, ASEAN Member States had signed 221 treaties with investment provisions (TIPs) under the framework of bilateral FTAs and 287 bilateral investment treaties (BITs) with countries that are not ASEAN Member States. More TIPs and BITs are in the process of negotiation or finalization. The proliferation of these agreements underscores the Member States' commitment to attracting FDI and strengthening investment relationships with partner economies.

2.3. FDI POLICY MEASURES

The region's investment policy environment has been shaped by the adoption and implementation of regional agreements and initiatives as well as by national policy measures. At the national level, measures adopted by Member States in 2018–2019 and during the pandemic (2020) were mostly favourable to investors. Member States also signed more international investment agreements (i.e. bilateral FTAs with investment chapters and BITs).

2.3.1. Regional agreements

In 2018–2020, Member States concluded at least 14 major regional agreements or initiatives that have implications for the region's investment environment and connectivity (table 2.3). They cover commitments to further strengthen cooperation in investment and in the development of e-commerce, digital economy, smart cities, Industry 4.0 transformation, trade in services and customs integration. Member States also agreed on coordinated strategy and actions for post-pandemic recovery. New FTAs with partner economies, including protocols to upgrade the main agreements to strengthen investment provisions, were also adopted.

(a) Liberalization agreements and actions

Under the ACIA, Malaysia modified its reservation list in 2018. The changes, which were favourable to FDI, covered technical refinements for clarity and transparency. Hot-rolled steel bars and wire rods were removed from the list of closed sectors, while steel billets were removed from the list of closed sectors subject to meeting certain conditions. Sugar refining, which was previously closed for investment, was moved to the list of sectors with specific conditions. In 2019, the Philippines modified its reservation list, liberalizing access to foreign exchange resources by removing the previous condition for registration requirements for loans.

Table 2.3. Major ASEAN agreements or initiatives with implications for FDI, 2018–2020

Agreement	Date signed/ established	Objective/Remark
ASEAN Smart Cities Network	April 2018	A collaborative platform for cities in ASEAN to work towards the common goal of smart and sustainable urban development
ASEAN Digital Integration Framework	August 2018	Strengthens digital integration in the region, so as to strengthen connectivity, efficiency and business environment
Protocol to implement the tenth package of commitments under the ASEAN Framework Agreement on Services (AFAS)	November 2018	Provides the final set of commitments of ASEAN Member States in opening up the services sectors (except financial and air transport services) before transitioning into the ASEAN Trade in Services Agreement
ASEAN Agreement on Electronic Commerce	January 2019	Facilitates cross-border e-commerce transactions in ASEAN so as to develop and intensify the use of e-commerce in the region
Protocol to implement the eighth package of commitments on financial services under AFAS	April 2019	Provides the latest set of commitments of ASEAN Member States in opening up the financial services sector
ASEAN Declaration on Industrial Transformation to Industry 4.0	November 2019	Aims to strengthen cooperation and maximize opportunities from Industry 4.0 through adoption and diffusion of innovation and related technologies
Declaration of the Special ASEAN Summit on Corona-virus Disease 2019 (COVID-19)	April 2020	Stresses collective action and coordinated policies in mitigating the economic and social impacts from the pandemic; among others, to keep the region open for trade and investment, and enhance cooperation in supporting the sustainability of regional supply chains
Hanoi Plan of Action on Strengthening ASEAN Economic Cooperation and Supply Chain Connectivity in Response to the COVID-19 Pandemic	June 2020	Emphasizes regional cooperation to keep ASEAN markets open, ensure smooth flow of supply chains and not impose export bans
Fourth Protocol to Amend the ASEAN Comprehensive Investment Agreement (ACIA)	July 2020	Incorporates WTO trade-related investment measures, prohibitions on performance requirements and a "two-annex" approach for negative-list reservations, one that lists non-conforming measures that remain and one that lists related sectors or subsectors that were not liberalized
ASEAN-Wide Self-Certification (AWSC) Scheme	September 2020	Allows certified exporters to self-certify the origin of their goods for preferential tariffs under the ASEAN Trade in Goods Agreement, facilitating easier and lower-cost intraregional movement of goods
ASEAN Trade in Services Agreement	October 2020	Aims to increase trade and investment in services by (i) providing larger markets and opportunities for economies of scale, (ii) reducing barriers to trade and investment in services, (iii) creating a predictable business environment and (iv) promoting regulatory cooperation
Regional Comprehensive Economic Partnership (RCEP) Agreement	November 2020	Covers measures on investment, trade in goods and services, and economic integration between the 15 Contracting Parties (ASEAN plus five), with important implications for FDI
ASEAN Comprehensive Recovery Framework	November 2020	Serves as the region's consolidated pandemic crisis exit strategy; contains broad strategies and measures by focusing on key sectors, including in attracting FDI
ASEAN Customs Transit System	November 2020	Aims to facilitate cross-border land transportation of goods

Source: ASEAN Secretariat.

(b) Facilitation-related agreements

In supporting the development of e-commerce and the internet economy, Member States have adopted a number of regional agreements or initiatives to help businesses and citizens benefit from opportunities presented by the rapidly growing digital economy. The ASEAN Agreement on Electronic Commerce was signed on 22 January 2019. It aims to facilitate cross-border e-commerce transactions, create an environment of trust and confidence in the use of e-commerce, and build greater digital connectivity in the region.

The ASEAN Digital Integration Framework, adopted on 29 August 2018, aims to strengthen digital integration. It consists of six priority areas to (i) facilitate seamless trade, (ii) protect data while supporting digital trade and innovation, (iii) enable seamless digital payments, (iv) broaden the digital talent base, (v) foster entrepreneurship and (vii) facilitate regional coordination efforts. The digital cooperation led to other significant regional initiatives and institutional development, such as the ASEAN Data Management Framework, the ASEAN Framework on Personal Data Protection and the ASEAN Cross-Border Data Mechanism, which are being implemented. To guide digital cooperation in 2021–2025, the ASEAN Digital Masterplan 2025 was adopted at the first meeting of the ASEAN Digital Ministers on 22 January 2021.

The region is also cooperating on the transformation to Industry 4.0. This led to the ASEAN Declaration on Industrial Transformation to Industry 4.0, which was adopted on 2 November 2019. The Member States aim to prepare for and maximize opportunities from Industry 4.0, by adopting and diffusing innovations and technologies such as the internet of things, big data, cloud-based technology, artificial intelligence and additive manufacturing (chapter 4).

Other regional initiatives that have implications for increasing the efficiency of ASEAN for business and investment include (i) the ASEAN Smart Cities Network (established in 2018) and (ii) the ASEAN Comprehensive Recovery Framework adopted in 2020. The Framework serves as a coordinated strategy to guide the post-pandemic recovery. It contains a broad range of sectoral measures, including some targeted at attracting FDI. An ASEAN Investment Facilitation Framework is in development. It will contain non-legally binding guiding principles and actions to (i) improve accessibility, transparency of investment rules, regulations and procedures; (ii) streamline and expedite administrative procedures and requirements for entry, retention and expansion of investment; and (iii) create favourable conditions for investment and for doing business. It is expected to be adopted in 2021. In the area of customs integration and cooperation, an ASEAN-wide Self-Certification was implemented on 20 September 2020 to facilitate trade in the region. It simplifies customs procedures by allowing certified exporters (i.e. exporters who have demonstrated competence in complying with the ATIGA rules of origin requirements) to self-certify the status of their goods to benefit from preferential tariffs under the ATIGA.[1] On 30 November 2020, six ASEAN Member States (namely, Cambodia, the Lao People's Democratic Republic, Malaysia, Singapore, Thailand and Viet Nam) officially launched the live operation of the ASEAN Customs Transit System, an online transit management system, to facilitate cross-border land transport of goods between the participating countries.[2] The system aims to improve efficiency in delivery, reduce costs and provide better connectivity in the movement of goods by land transportation across the participating Member States.

Customs integration was further extended with the live exchange of the ATIGA e-Form D in December 2019, through the ASEAN Single Window (ASW). The e-Form D is expected to facilitate intraregional trade, reduce cost and supports regional production networks. In 2020, more than 800,000 ATIGA e-Form D were exchanged in the region.[3] In December 2020, Cambodia, Myanmar and Singapore started exchanging the ASEAN Customs Declaration Document through the ASW. The ASW connects and integrates national single windows, and facilitates exchange of electronic trade-related documents. The system enables a single submission of data, synchronous processing of information and decision-making for customs release and clearance in the region.

(c) Promotion actions

Many regional events were held in 2018–2020 to promote investment opportunities and increase transparency about and awareness of regional integration. They included the various ASEAN Investment and Business Summits organized at the fringes of ASEAN Summits and Related Meetings in 2018, 2019 and 2020. Information on investment and business opportunities in ASEAN was also published regularly. For instance, in 2020 an e-brochure "Investment Opportunities in ASEAN 2021 – Invest in ASEAN: Towards Resilient Growth in the New Normal" was published by the ASEAN Secretariat to promote investment in the region. The *ASEAN Investment Report*, analysing FDI development and MNE activities through a regional integration lens, has been published annually since the 1990s. In 2018, the report analysed FDI and the digital economy in ASEAN and in 2019, FDI in services in ASEAN, with a focus on health care.

The ASEAN Secretariat has continued to provide and disseminate information related to investment and the outcome of major meetings on the Secretariat's website.[4] The ASEAN Solutions for Investments, Services and Trade (ASSIST) facility added a trade-in-service component to the portal in May 2019. ASSIST is a non-binding consultative mechanism for solving operational problems encountered by ASEAN enterprises on cross-border issues related to the implementation of ASEAN economic agreements.[5]

(d) Extra-ASEAN free trade agreements

A major development related to ASEAN FTAs was the signing of the RCEP Agreement in 2020 (section 2.6). Other agreements signed during 2018–2020 included the first Protocol to Amend the ASEAN–Japan Comprehensive Economic Partnership Agreement in 2019. The amendment incorporates chapters on trade in services, movement of natural persons and investment. The ASEAN–Hong Kong, China SAR Investment Agreement entered into force in June 2019.

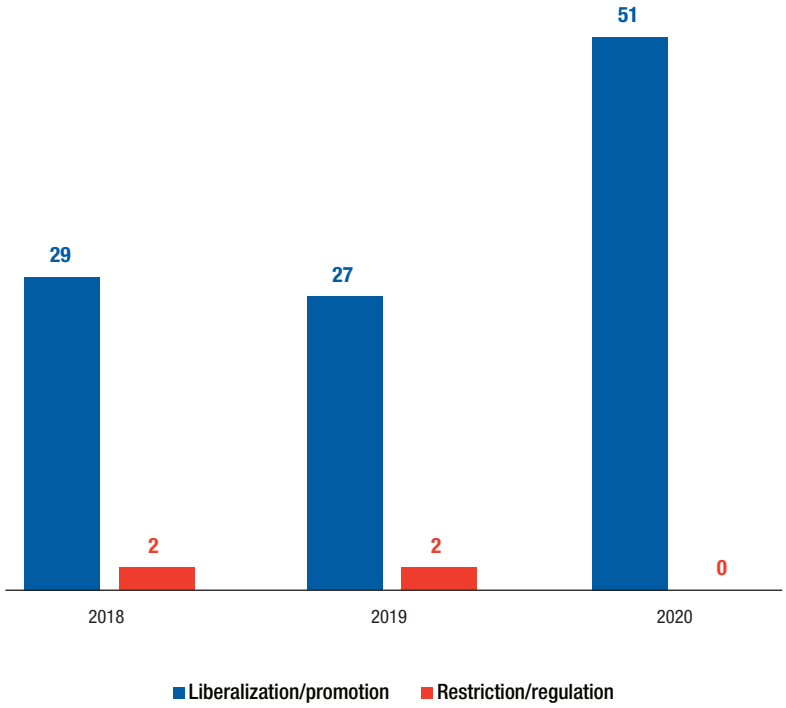
ASEAN and some partner economies are also working on upgrading existing agreements: (i) the ASEAN–Australia–New Zealand FTA, including the investment chapter, and (ii) the ASEAN–China Investment Agreement, in particular the investment liberalization and protection components. Preparations are also being made to launch the negotiations for the ASEAN–Canada FTA.

ASEAN Member States (i.e. Cambodia, the Lao People's Democratic Republic, Malaysia, Myanmar and Singapore)[6] are participating in the negotiations on Investment Facilitation for Development at the WTO. The negotiations involve more than 100 volunteer WTO members and aim to establish a "more transparent, efficient and investment-friendly business climate".[7]

2.3.2. National measures

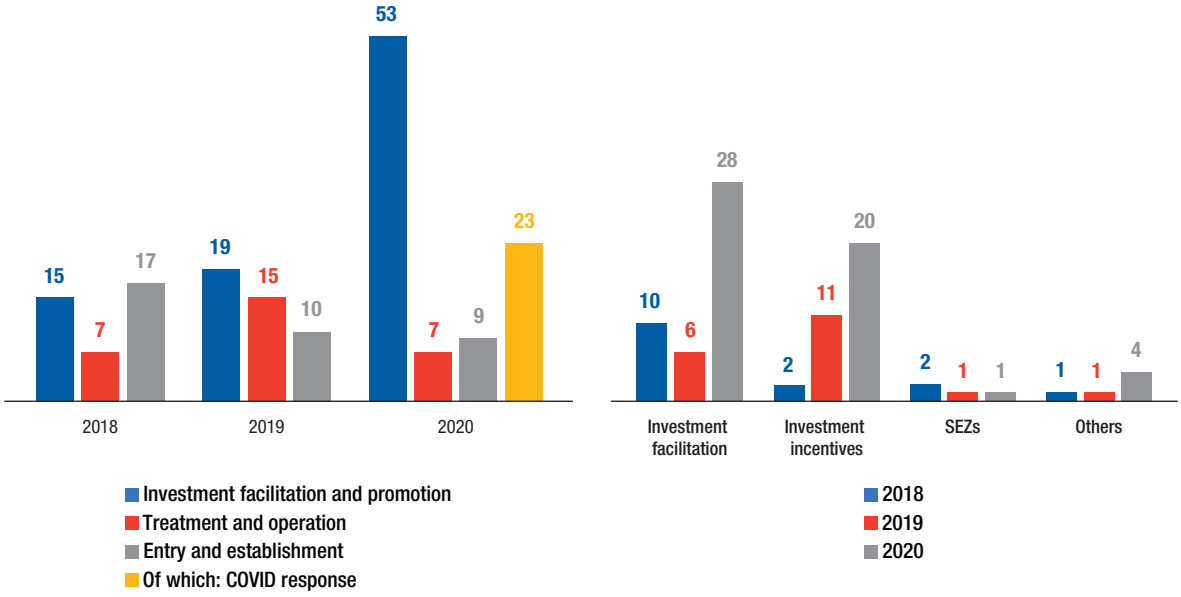
During 2018–2020, Member States continued to adopt investment policy measures favourable to FDI, with few restrictions or regulations limiting investment (figure 2.1). The number of measures or laws favourable to investment rose from 27 in 2019 to 51 in 2020. Many more measures favourable to FDI were introduced in 2020 than in the preceding two years. Most measures related to facilitation and promotion of investment, and to specific types of investment related to COVID-19 (figure 2.2a). Investment incentives (e.g. special tax incentives, tax and duties reduction, defer payment of tax and duties) and facilitation measures (e.g. simplification of investment processes, extended services to investors and introduction of online system) were the overwhelming focus in all three years, but were significantly more conspicuous in 2020 (figure 2.2b).

Figure 2.1. ASEAN: National investment policy measures adopted, 2018–2020 (Number)



Sources: ASEAN Secretariat and UNCTAD IPM database.
Note: Includes business measures that could have an impact on investment environment (e.g. business facilitation measures and pandemic economic relief packages such as fiscal incentives, deferred duty and tax payments). Excludes trade-related measures and measures classified as neutral (e.g. directives or acts that aim to ensure consistency of laws and to align insolvency rules to national laws).

Figure 2.2. ASEAN: National investment policy measures adopted, by category, 2018–2020 (Number)



Sources: ASEAN Secretariat and UNCTAD IPM database.
Note: A measure could be counted two or more times under different categories. Other measures under investment facilitation and promotion include establishment of an investment ministry or an investment promotion committee. Relevant COVID-19 response measures are included in the investment facilitation and promotion category.

(a) Liberalization measures

During this period, some Member States amended or enacted new investment-related laws and regulations, mostly favourable to investment (table 2.4, annex 2.1). For instance, Brunei Darussalam, Indonesia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam enacted new or amended existing laws to further improve their investment environment or legal framework. These new or revised laws cover areas such as providing a more coherent legal framework consistent with other national regulations, permitting FDI in additional business areas, reducing or eliminating barriers to investment, harmonizing sector-specific laws and regulations, allowing 100 per cent foreign equity ownership in large-scale infrastructure projects, and providing investment guarantees, national treatment and market access.

Indonesia deregulated 222 of 225 regulations as of January 2019. The Government is relaxing immigration rules and harmonizing various sector-specific laws and regulations under Ministry of Trade Regulation No. 50 of 2020, implemented in May. It also enacted the Omnibus Law on 2 November 2020 to improve the ease of doing business and facilitate investment, such as by simplifying licensing processes and providing incentives. The *Philippines* promulgated its 11th Regular Foreign Investment Negative List (Executive Order No. 65) in October 2018, further opening up some business areas to 100 per cent foreign participation.

In June 2020, *Viet Nam* amended its Law on Investment 2019 and its Law on Enterprises 2019, to create a more favourable investment environment. The amended Law on Investment further liberalizes the investment regime. For instance, it defines a foreign investor as holding an equity interest of 50 per cent or more (instead of the previous 51 per cent), provides investment guarantees (e.g. property ownership and the right to transfer assets abroad) and grants national treatment for market access to foreign investors.

Some Member States are in the process of enacting new laws relating to investment. *Cambodia* has finalized a new draft Law on Investment and is in the process of seeking approval from the Parliament. The draft law aims to further attract investment, support technology transfer, create jobs and enhance skills development. Cambodia is also in the process of drafting a law on special economic zones (SEZs). Indonesia has announced plans to release new economic reform packages, following from the 16 economic policy packages completed in 2018. The new packages address logistics, agrarian reform, energy, food, the creative economy, industries and services. With the aim to further streamline and simplify its law and regulations, *Thailand* is implementing a "regulatory guillotine" initiative, which reviews any legal acts, licenses or regulations that are no longer necessary, out-of-date and constraining doing business.

Table 2.4. National laws and acts with implications for FDI (Selected cases)

Country	Instrument or law	Objective	Date	Remarks
Brunei Darussalam	Companies Act Order and Companies (Striking Off) Rules	Amendment	Effective 13 September 2018	Strengthens the Companies Act (Chapter 39) to ensure a more effective enforcement system for striking off companies from the Register
	Insolvency Rules 2018	Introduction of new rules	Effective 19 September 2018	Strengthens the country's insolvency legal framework
Indonesia	Omnibus Law	New law	November 2020	Increases the ease of doing business and facilitates investment (e.g. simplifying licensing processes, providing incentives, amending Labour Law regulations, relaxing immigration rules and harmonizing various sector-specific laws and regulations)
Lao People's Democratic Republic	Article 12 of the 2016 Law on Investment Promotion, No. 14/Na	Amendment	December 2019	Achieves consistency with the Law on Value Added Tax and other relevant national regulations
	Law on Land No. 70/Na	Amendment	August 2020	Permits foreign investors to own apartments and invest in condominium construction
Myanmar	Tourism Law	New law	17 September 2018	Covers license application for tourism services
	Trade Mark Law	New law	30 January 2019	New laws related to intellectual property rights
	Industrial Design Law	New law	30 January 2019	
	Patent Law	New law	11 March 2019	
	Copyright Law	New law	24 May 2019	
	Insolvency Law	New law	14 February 2020	Covers implementing rules on insolvency
	Industrial Zone Law	New law	26 May 2020	Covers establishment of industrial zones

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Table 2.4. National laws and acts with implications for FDI (Selected cases) (Concluded)

Country	Instrument or law	Objective	Date	Remarks
Philippines	Innovative Startup Act	New law	26 April 2019	Consists of programmes, benefits and incentives for start-ups and start-up enablers
	An investment circular	New circular	30 October 2020	Allows 100 per cent foreign ownership in large-scale renewable energy (geothermal) projects
Singapore	Companies Act	Amendment	Effective 31 August 2018	Ensures that Singapore remains business friendly and competitive
	Variable Capital Companies Act 2018	New law	Effective 14 January 2020	Provides for the incorporation, operation and regulation of variable capital companies, a new corporate structure for investment funds that complements the existing suite of investment fund structures available in Singapore.
Thailand	Electronic Transactions Act	New law	14 April 2019	Relates to Thailand 4.0 digital reform initiative and covers data protection and cybersecurity
	Personal Data Protection Act	New law	27 May 2019	
	Cyber Security Act	New law	27 May 2019	
Viet Nam	Law on Investment 2019	Amendment	17 June 2020	Aims to create a more favourable, transparent, fair and safe business and investment environment
	Law on Enterprises 2019	Amendment	17 June 2020	Covers investment guarantees, additional incentives, national treatment and investment dispute settlement
	Law on Public-Private Partnership (PPP) Investment	New law	18 June 2020	Creates a more stable legal environment for PPP projects
	Negative list	Investment list	2020	Provides foreign investors with national treatment and market access except in sectors in the negative list

Source: ASEAN Secretariat.

(b) Investment facilitation and promotion measures

During this period, Member States introduced specific investment facilitation measures that further streamlined and simplified investment processes to improve efficiency and make investing in the country easier (table 2.5, annex 2.2). Some actively promoted the use of online facilities. Additional online facilities were created to support investors and expand services. Continued consultations with the private sector were undertaken to identify actions to further improve the investment environment and support businesses. Most Member States continued to develop SEZs and promote investment in industrial estates to facilitate FDI. Member States remain committed to developing and upgrading infrastructure, including attracting private investment.

Table 2.5. National investment facilitation and promotion measures adopted in 2018–2020 (Selected cases)

Country	Measure	Category	Date introduced or announced	Remarks
Brunei Darussalam	Simplified procedures to start a business	Simplify procedure	..	Improve ease of doing business
	Removed stamp requirement for share certificates	Reduce administrative requirements	..	Improve ease of doing business
	Streamlined approval for getting electricity	Simplify procedure	..	Improve ease of doing business
	Established BusinessBN website	Online system	..	Provide information on government processes
	Conducted workshop	Private sector engagement	..	Engage business community to further improve and streamline business-related processes and regulations
Cambodia	Implemented online system for investment applications	Online system	June 2020	Improve ease of doing business
	Approved investment applications within eight working days	Reduce red tape	June 2020	Improve ease of doing business
	Held regular Government–private sector forum and consultation	Private sector engagement	Annual	Aftercare service
Indonesia	Established online single submission	Online system/ reduce red tape	July 2018	Establish an online business licensing system to reduce red tape
	Harmonized regulations	Streamline	Late 2018	Part of the 16 Economic Policy Packages
	Simplified bureaucratic processes	Simplify procedure	Late 2018	Part of the 16 Economic Policy Packages
	Deregulated	Deregulation	January 2019	Deregulate 222 of 225 regulations
	Simplified business licensing and advertising in e-commerce	Simplify procedure	May 2020	Implement MOT Regulation No. 50 of 2020
	Provided incentives	Incentives	November 2020	Omnibus Law 2020
	Simplified licensing	Simplify procedure	November 2020	Omnibus Law 2020
	Harmonized sector-specific laws and regulations	Harmonization of instruments	November 2020	Omnibus Law 2020
Lao People's Democratic Repulic	Simplified procedures for obtaining license and company registration	Simplify procedure	February 2018	Prime Minister's Order No. 02/PM
	Improved issuance process of investment and business licenses	Reduce red tape	January 2020	Prime Minister's Order No. 03/PM
	Published guidelines on fiscal incentive policy and leasing fee	Information provision	..	Announced process of issuing guidelines on fiscal incentives and leasing fees or concessions for loan for investment application

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Table 2.5. National investment facilitation and promotion measures adopted in 2018–2020 (Selected cases) (Continued)

Country	Measure	Category	Date introduced or announced	Remarks
Myanmar	Launched Myanmar Companies Online	Online system	August 2018	Pursuant to Myanmar Companies Law, 1 August 2018
	Announced online investment appliication system	Online system	Late 2020	In preparation
	Established the Investment Promotion Committee	Institutional development	October 2018	In relation to Myanmar Investment Promotion Plan, October 2018
	Launched the Myanmar Investment Promotion Plan	Promotion strategy	October 2018	Announced investment promotion strategies
	Implemented investor grievance mechanism	Grievance mechanism	April 2020	Establishe the Investor Grievance Mechanism (IGM) Committee with Notification No. 21/2020 on 21 December 2020
	Reduced fees for company incorporation and lodgement of annual returns	Fees reduction	September 2019	Notification No. 84/2019 of the Directorate of Investment and Company Administration, 20 September 2019
	Implemented disclosure of beneficiary ownership information	Disclosure requirement	November 2019	Directive No. 17/2019 by the Directorate of Investment and Company Adminstration
	Permit for investment expansion	Investment facilitation and expansion	August 2020	Notification No. 15/2020 on expansion of volume of investment during the permitted period of investment by the Myanmar Investment Commission on 14 August 2020
Philippines	Streamlined government services	Simplify procedure	May 2018	Republic Act No.11032, 28 May 2018
	Began issuing Startup Visas	Foreign personnel	..	Innovative Startup Act
	Eliminated overregulation	Simplify procedure	February 2020	Administrative Order No. 23, 21 February 2020
	Added duty exemption	Incentives	July 2019	Provides duty-free importation of equipment, spare parts and accessories under projects approved by the Board of Investment, Executive Order No. 85, 19 July 2019
Singapore	Consolidated LicenceOne into GoBusiness	Online	April 2021	Information from multiple government agencies required to start a new business (including the functionalities of LicenceOne) were consolidated under the new GoBusiness portal, which aims to provide a single digital touchpoint for businesses to transact with the Singapore Government
	Launched LicenceOne	Online	October 2019	Establish an online licensing portal for application of licenses and permits
	Modified STAR e-Lodgement system	Simplify procedure	June 2018	Streamline land administration process
	Simplified filing of annual returns	Simplify procedure	December 2019	Private companies verify information in pre-filled annual returns is correct before submission
	Implemented Patent Fast-Track Programme	Accelerate application	May 2020	Expedite application-to-grant process of technology patents, from two years to six months

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Table 2.5. National investment facilitation and promotion measures adopted in 2018–2020 (Selected cases) (Concluded)

Country	Measure	Category	Date introduced or announced	Remarks
Thailand	Began "regulatory guillotine" initiative	Simplify procedure	Ongoing	Further streamline and simplify Thailand's law and regulations
	Launched e-submission service	Online	March 2020	Launch an online document submission service in addition to existing investment e-services
	Launched investment incentives	Incentives	2019	Offer incentives for large-scale investment in technology-advanced industries, projects in the Eastern Economic Corridor and smart city development
	Established SMART Visa online clinic	Consultation service	February 2018	Offers information on various administrative issues, processes, documentation, benefits and incentives
	Launched "Thailand Plus" programme	Incentives	September 2019	Provides additional tax incentives for large high-tech projects and for developing human resources for a highly skilled workforce
	Promoted investment	Seminar	2019	Promotes investment opportunities in the Eastern Economic Corridor
Viet Nam	Implemented measures to further improve business environment	Business environment	January 2020	Resolution No. 02/NQ-CP, 1 January 2020

Sources: ASEAN Secretariat and media.

(c) Tax incentives

Some Member States reformed tax systems or extended or provided additional investment incentives during 2018–2020 (section 2.5). These measures included tax holidays and duties exemption on importation of plants and equipment. In 2020, most Member States also allowed deferred payments of taxes and duties and filing of tax returns as part of their pandemic-response measures.

Brunei Darussalam established an Income Tax Board of Review to facilitate the administration and operation of taxation through a new process of hearing, examination and settlement of company cases against the assessment of the Collector of Income Tax. *Cambodia* continued with implementation of online value added tax refunds and credits. It also announced plans for tax incentives to expand investment projects in the country. *Indonesia* issued a new tax holiday policy (Regulation No. 150/PMK.010/2018 dated 27 November 2018) to boost investment in industry. The recently enacted Omnibus Law (2 November 2020), which covers many aspects of investment measures in Indonesia, provides additional investment incentives to investors. The *Lao People's Democratic Republic* introduced a customs and value added tax incentive for importation by enterprises in accordance with its investment promotion policy No. 01/CCIPM (2 January 2019). The *Philippines* enacted the Innovative Startup Act, which provides benefits and incentives for start-ups and start-up enablers, on 26 April 2019. Also in 2019, *Thailand* extended an investment incentives package for projects in the Eastern Economic Corridor, and for knowledge-based, high-tech and high value added activities. Smart city development

activities are eligible and privileges are offered over an extended period for tax exemption, import duty exemption and reduction of corporate income tax. Under the stimulus package called Thailand Plus (introduced on 6 September 2019), additional tax incentives were offered to (i) investment in large projects that focus on high-tech industries and (ii) projects that develop human resources and a highly skilled workforce. *Viet Nam* amended its Law on Investment in 2019 to provide additional investment incentives.

(d) Other investment facilitation measures

Some Member States adopted trade facilitation measures, which could have implications for export-oriented FDI activities. For instance, Cambodia eliminated issuance of certificates of origin for goods exported to countries that do not require a certificate of origin form and reduced scanning fees for export and import of garments, footwear and rice products.

(e) Regulation/restriction measures

A few Member States enacted regulations that require exporters to obtain an approval letter from the relevant authority for export of medical goods (e.g. surgical face masks) or to restrict certain medical exports in the period under review. Cambodia, the Philippines, Thailand and Viet Nam introduced temporary export bans on medical products in 2020. Myanmar modified regulation of companies to provide clarity of information such as disclosure of beneficial owners of investment in the extractive industry.

(f) Other measures and initiatives related to FDI

During this period, Member States enacted other measures related to FDI, such as those that have an impact on the general business environment and industrial development. They also introduced measures aiming to attract investment for the development of industrial estates and SEZs, which play an important role in improving a country's investment environment and make it easier to set up production facilities. All Member States continued to develop and upgrade infrastructure by encouraging participation by the private sector, including foreign investors. They provided investment incentives and issued concessions. For instance, they rolled out 5G licenses and encouraged telecommunication MNEs to participate in the development of 5G networks (chapter 3).

General business environment

In addition to specific FDI-related measures, Member States are implementing economic or industrial development plans (box 2.1), attracting investment in the development of smart cities and introducing national strategies for Industry 4.0 transformation (see chapters 3 and 4). Some measures adopted by Member States aim at improving the ease of doing business and reducing transaction costs. For example, the *Lao People's Democratic Republic* implemented Prime Minister's Order No. 02/PM (February 2018) on improving the ease of doing business. The *Philippines* enacted in May 2018 the Ease of Doing Business and Efficient Government Services Law. *Viet Nam* issued on 1 January 2020 Resolution No. 02/NQ-CP to further improve the country's business environment and enhance national competitiveness, including in e-government.

Box 2.1. ASEAN Member States: Economic and industrial development plans (Selected cases)

Some Member States recently launched revised national development plans and visions for economic and industrial development. They implemented policies and measures to support development priorities and targets, which have implications and opportunities for FDI. For instance:

- *Brunei Darussalam* continued with economic diversification beyond the oil and gas industry to include other priority industries (i.e. downstream oil and gas, food, tourism, services, and information and communication technology (ICT)). Through implementation of the Financial Sector Blueprint, Brunei Darussalam aims to evolve into a hub for Islamic finance.
- *Cambodia* adopted the Cambodia Digital Economy and Social Policy Framework (2021-2030) on 10 May 2021. The policy sets out a long-term vision for building a vibrant digital economy and society by laying the foundations for promoting digital adoption and transformation in all sectors of society, and among states, citizens, and business, to accelerate new economic growth and improve social welfare in alignment with the "new normal" trajectory. In 2019, Cambodia promulgated the National Strategic Development Plan 2019–2023. The plan sets out a macroeconomic framework, policies and priority actions to realize Cambodia Vision 2030, in which the country aims to achieve upper-middle-income status by 2030 and high-income status by 2050. It is also implementing its Industrial Development Policy 2015–2025.
- The *Lao People's Democratic Republic* continued with its eighth Five-Year Plan (2016–2020), which aims to promote foreign and domestic private investment.
- *Malaysia* launched its Shared Prosperity Vision 2030 on 5 October 2019. It aims to achieve a decent standard of living for all citizens by addressing income and wealth inequality in shifting from a low-skilled, labour-intensive economy to a knowledge-based one. Malaysia is also formulating its New Industrial Master Plan (2021–2030) and the Twelfth Malaysia Plan (2021–2025).
- *Thailand* is implementing the first long-term National Strategy (2018–2037), by which it aims to achieve developed-country status by 2037.

Source: ASEAN Secretariat.

Special economic zones

Most Member States continued to develop more industrial estates and SEZs to facilitate investment (*AIR 2017, WIR 2019* and table 2.6). Examples include the Sihanoukville and Phnom Penh SEZs in Cambodia; Sei Mangkei, Morotai and MBTK SEZs in Indonesia; the East Coast Economic Region, Northern Corridor Economic Region and Iskandar SEZs in Malaysia; Thilawa in Myanmar. Another example is in Thailand with the Eastern Economic Corridors and Thai SEZs bordering Cambodia, the Lao People's Democratic Republic, Malaysia and Myanmar. Some SEZs in the region are huge, consisting of residential cities, ports and facilities targeting clusters of multiple industries. For instance, the Dawei SEZ under construction in Myanmar covers 196 km^2, and the SEZ of the Iskandar economic corridor in Malaysia encompasses 2,217 km^2.

Member States have also enacted special laws to govern the development of industrial estates or SEZs. In 2019–2020, some enacted new SEZ laws. *Myanmar* enacted the Industrial Zone Law (26 May 2020), which permits investment in manufacturing of finished goods, logistics services

Table 2.6. SEZs and economic corridors in ASEAN, 2020 (Number)

Country	SEZs or economic corridors		
	Announced or designated	In operation	Under construction
Brunei Darussalam	1	1	..
Cambodia	46	20	11
Indonesia	19	12	7
Lao People's Democratic Republic	14	12	2
Malaysia	5[a]	5	..
Myanmar	3	1	2
Philippines	12	12[b]	..
Singapore	10[c]	10	..
Thailand	10	10	..
Viet Nam	19[d]	19	..

Source: *ASEAN Investment Report 2020–2021* research, based on country websites.
Note: These SEZs are in addition to the many industrial parks that are in operation or being developed by investors and economic zone authorities. For more information on the more than 1,600 economic zones and industrial parks or facilities in the region, see *ASEAN Investment Report 2017*.
[a] A new type of SEZ, comprising economic corridors involving contiguous States.
[b] In addition, the country has 19 tourism SEZs.
[c] Represented by free trade zones.
[d] Comprises 15 economic zones, 3 EPZs and 1 high-tech park. Viet Nam has many industrial parks.

and trading. The *Philippines* signed Republic Act 11453 (30 August 2019) to convert the Bataan Economic Zone into an SEZ and freeport. Along with other territories indicated in the law, the SEZ will be known as the Freeport Area of Bataan. In 2021, *Cambodia* is reviewing the Law on Special Economic Zones. The law aims to promote the establishment of large industrial clusters within SEZs.

Infrastructure investment and development

The infrastructure investment needs in ASEAN, estimated at more than $110 billion per year through 2025, require the participation of private investors, including through FDI (*AIR 2015*). This estimate covers infrastructure for electricity, transportation and telecommunication. ASEAN Member States have continued to invest, develop and upgrade infrastructure (chapter 1), including in power generation, transportation and telecommunication, which have important implications for the general investment environment.

In the period under review, many investors from China, Japan, the Republic of Korea and ASEAN participated in infrastructure development through contractual arrangements. Some of the major infrastructure projects completed have significant impacts on logistics and on power supply and in improving the efficiency of the business environment. They include the following: *Brunei Darussalam* completed construction of the Pulau Muara Besar Bridge in May 2018, which enhanced transportation connectivity. The *Lao People's Democratic Republic* continued with various large infrastructure development projects such as the construction of the Vientiane–Vangvieng Expressway, the Lao–China Railway and the Xayaburi hydropower plant.

Thailand is developing major infrastructure such as (i) the High-Speed Rail Linked 3 Airport Project, (ii) the U-Tapao Airport, (iii) the Laem Chabang Deep Sea Port and (iv) smart cities, which includes upgrading the quality and standard of industrial estates with smart services.

Member States are cooperating in developing smart cities through regional initiatives. The ASEAN Smart Cities Network was established in 2018 to achieve smart and sustainable urban development, involving major cities in all 10 Member States. These smart cities, which are at different stages of development, use digitalization and other smart technologies for mass urban transportation, digital connectivity, flood management, traffic management and e-payment, among other systems. They are expected to improve the living environment in cities as well as efficiency. These smart cities are expected to have favourable impacts on the movement of people, connectivity, the ease of doing business and the efficiency of operating in them. The development of smart cities in ASEAN has benefited from partnerships with technology solutions providers such as ABB (Switzerland), Alibaba (China), Cisco (United States), Fujitsu (Japan), GE (United States) and Siemens (Germany).

Digitalization and Industry 4.0

All Member States have plans for digitalization and Industry 4.0 transformation (chapter 4). In 2018–2020, they introduced measures for the adoption of digitalization, including facilitating investment and trade through digital application processes and e-government systems. For instance, the *Philippines* granted investment incentives to prioritize the attraction of investment in high-tech activities that support innovation and adoption of Industry 4.0 technologies.

Malaysia introduced Industry 4.0 initiatives in June 2020, with two measures that facilitate and attract FDI in targeted areas:[8]

(i) The Dana Pelan Jana Semula Ekonomi Negara ("PENJANA") Nasional initiative to support digitalization of businesses by channelling funding from international investors to the local venture capital space. Target beneficiaries include start-ups and domestic venture capital funds. Some venture capital funds and international investors that are participating include 500 Startups (United States), Hanwha Asset Management (Republic of Korea), Provident Growth (Hong Kong, China), SK Group (Republic of Korea) and The Hive (United States).

(ii) The Malaysia as an Attractive Horizon for Businesses initiative (section 2.5), which includes enhancement of the Domestic Investment Strategic Fund Industry4WRD, to provide matching grants for local companies that seek investment in upgrading or enhancing technological capabilities to be more competitive internationally, so as to move up a company's value chain and enable the company to be an active participant in targeted industries such as in high value added, high-technology, knowledge-intensive and innovation-based activities.

In the Thailand 4.0 initiative, the Government aims to attract and facilitate investment in knowledge-based, high-tech and high value added activities. Thailand also provides additional tax incentives to attract accelerated, large, investment projects in high-tech industries, including those that would help develop a skilled workforce.

2.3.3. International investment agreements

Individual ASEAN Member States have also entered into or upgraded FTAs and BITs with many countries outside the region. FTAs that include a chapter covering investment are referred to here as TIPs. There are 221 TIPs and 287 BITs involving ASEAN Member States with a non-ASEAN country or region as of April 2021 (table 2.7). The number of TIPs signed by ASEAN countries rose 36 per cent and the number of BITs with non-ASEAN countries by 12 per cent between 2011 and 2021. In 2018–2020, ASEAN Member States concluded 10 bilateral TIPs (box 2.2). The proliferation of TIPs and BITs underscores the commitment of ASEAN Member States to promoting FDI and strengthening investment relationships with partner economies or regions.

Table 2.7. International investment agreements signed by ASEAN Member States as of 2011 and 2021 (Number)

	As of 2011			As of 2021		
Country	**TIPs**	**BITs with other ASEAN countries**	**BITs with non-ASEAN countries**	**TIPs**	**BITs with other ASEAN countries**	**BITs with non-ASEAN countries**
Brunei Darussalam	16	-	7	21	-	7
Cambodia	13	6	14	16	6	20
Indonesia	14	2	38	21	3	38
Lao People's Democratic Republic	14	6	16	17	6	17
Malaysia	19	3	62	26	3	63
Myanmar	12	4	2	16	5	5
Philippines	13	5	32	17	5	32
Singapore	26	3	22	37	5	38
Thailand	20	6	32	24	6	33
Viet Nam	16	7	31	26	8	38
Total	**163**	**42**	**256**	**221**	**47**	**287**

Source: UNCTAD, IIAs database.
Note: BIT = bilateral investment treaty, TIP = treaty with investment provisions. TIPs include bilateral and regional FTAs with investment chapters. Data for 2011 are as of December and data for 2021 are as of April.

Box 2.2. Recent bilateral TIPs in ASEAN

ASEAN Member States continued to sign or upgrade bilateral TIPs in 2018–2020. They include the following:

Indonesia

- European Free Trade Association States–Indonesia Economic Partnership Agreement (2018), signed in December 2018
- Australia–Indonesia Comprehensive Economic Partnership Agreement (CEPA) (2019), signed in March 2019, entered into force in July 2020
- Republic of Korea–Indonesia CEPA (2020), signed in December 2020

Singapore

- Singapore–Sri Lanka FTA, entered into force in May 2018
- EU–Singapore FTA and EU–Singapore Investment Protection Agreement, signed on 15 October 2018
- China–Singapore FTA, upgraded in 2018 (announced on 5 November 2018)
- New Zealand–Singapore Closer Economic Partnership Agreement, upgraded in May 2019
- Singapore–United Kingdom FTA, signed on 10 December 2020

Philippines

- European FTA–Philippines FTA, signed in April 2016, entered into force in June 2018

Viet Nam

- EU–Viet Nam Investment Protection Agreement, signed on 30 June 2019
- United Kingdom–Viet Nam FTA, signed on 29 December 2020

Source: ASEAN Secretariat.

(a) Ongoing FTA negotiations

Some Member States are involved in ongoing negotiations of bilateral FTAs with other partner countries or regions. *Cambodia* is negotiating separate FTA agreements with China, the Eurasian Economic Union and India. *Indonesia* is doing the same with the European Union. *Malaysia* is negotiating an FTA with the European Free Trade Association and expanding the scope of its existing FTA with Turkey. *Singapore* is negotiating FTAs with the Eurasian Economic Union, MERCOSUR (the Common Market of the South), and the Pacific Alliance, and *Thailand* is doing so with the European Union.

(b) Bilateral investment treaties

ASEAN Member States signed an extensive number of BITs among themselves and with third countries (table 2.7). In 2018–2020, five ASEAN Member States signed and/or ratified 11 BITs (of which two are between two ASEAN Member States).

BITs between ASEAN Member States

(i) Indonesia and Singapore signed a BIT on 11 October 2018, which entered into force on 9 March 2021.

(ii) Myanmar and Singapore signed a BIT in September 2019, which entered into force on 9 October 2020.

(iii) Cambodia and Myanmar continued to negotiate a BIT in 2020.

BITs between ASEAN and non-ASEAN countries

Three BITs entered into force in 2018. ASEAN countries also signed three BITs in 2018 and ratified three in 2019:

(i) The Myanmar–Republic of Korea Agreement on the Promotion and Protection of Investment, signed in 2014, came into force on 31 October 2018.

(ii) Singapore signed new BITs with Kazakhstan, Rwanda and Kenya during May 2018 and May 2019. Two BITs, one with the Islamic Republic of Iran (signed in February 2016) and the other with Qatar (signed in October 2017), entered into force during 2018.

(iii) Cambodia ratified BITs with Bangladesh, the United Arab Emirates and Turkey on 12 July 2019.

(iv) Indonesia signed BIT with the United Arab Emirates on 24 July 2019.

2.4. PANDEMIC-RESPONSE MEASURES

The outbreak of the pandemic affected the investment plans of MNEs in the region, an impact that manifested in lower numbers of realized investments and fewer investment applications. The corporate earnings hit, lockdown measures and economic slowdown led to a 25 per cent decline in FDI across the region in 2020. Although FDI was down, some Member States fared better than other countries in attracting FDI during the pandemic year. The pandemic also significantly disrupted supply chains and production. In some industries, MNEs scaled down operations as they could not operate at full capacity.

A series of regional and national pandemic-response packages were enacted to mitigate the impact on investment and businesses. Most measures related to promotion and facilitation of investment. At the regional level, Member States agreed on the importance of ensuring undisrupted supply chains and of not banning export of health care and essential products.

2.4.1. Regional measures

At the early stage of the pandemic response, Member States enacted trade regulatory measures on essential goods, including health products. A temporary restrictive measure on export bans for health care products was introduced, which was subsequently lifted. Measures favourable to trade and production of health care products were also enacted. They included elimination of import tariffs and relaxed import certification requirements and import license fees (e.g. COVID-19 test kits, raw materials to fabricate masks, PPE, ethyl alcohol (raw materials) and face masks) (table 2.8).

Table 2.8. ASEAN: Early trade-related measures on essential goods during the pandemic

Country	Measures
Brunei Darussalam	Temporary reduction of import duties on personal hygiene products (e.g. masks, PPE)
Cambodia	Temporary export ban on COVID-19-related products (face masks)
Indonesia	Temporary elimination of import certification requirements, including deferred payment of excise duties on imports and elimination of import tariffs on certain medical and pharmaceutical products
Lao People's Democratic Republic	Exemption of duties and fees on import of masks, hand sanitizers, gloves, temperature measurement and other necessary medical supplies related to the pandemic
Malaysia	Temporary elimination of import tariffs on face masks, PPE, medical equipment and raw materials (ethyl alcohol), as well as exemption of sales taxes and excise duties on such imports
Myanmar	Temporary elimination of import license fees on medicines and raw materials used in medicines, as well as waivers on commercial tax for medical supplies and pandemic-related products Trade financing and facilitation of exports
Philippines	Temporary export ban and elimination of import tariffs, taxes and fees on pandemic-related medical products
Singapore	Temporary relaxation of import licensing requirements for hand sanitizers, masks, thermometers and protective gear, as well as elimination of import tariffs and a ban on export prohibition
Thailand	Temporary export ban on surgical and face masks, as well as exemption from custom duties on import of pandemic-related medical products and health care equipment
Viet Nam	Temporary export ban on certain COVID-19 drugs, elimination of import taxes, imposition of temporary export licensing requirements (on face masks) and elimination of import tariffs (on non-woven fabrics for production of protective clothing)

Sources: ASEAN Secretariat and media.
Note: PPE = personal protective equipment. Measures mostly relate to masks, raw materials for producing disinfectants, PPE and medicines.

Since May 2020, Member States have cooperated to keep economies in the region open to facilitate cross-border trade and investment. They agreed in June 2020 to the 2020 Hanoi Action Plan on Strengthening Supply Chain Connectivity in Response to the COVID-19 Pandemic to ensure a smooth flow of essential goods (e.g. food, medicines and medical supplies) in ASEAN. They also agreed to strengthen the resilience of regional supply chains in collaboration with private development partners. In addition, they agreed through a memorandum of understanding not to impose restrictive trade measures for two years, and to unilaterally roll back all non-tariff measures on essential goods and supplies that are not in conformity with the WTO Agreement that entered into force on 13 November 2020.

Some Member States with contiguous borders cooperated to ease movement in supply chains. In ensuring seamless supply chains and ease of movement of goods, the Royal Malaysian Customs Department (RMCD) encourages companies to use the authorized economic operator platform, which can expedite customs clearance. In addition, the use of e-Movement System initiated by RMCD Sarawak at all customs, immigration and quarantine complexes bordering Brunei Darussalam has facilitated movement of goods through Brunei Darussalam. Both countries have observed the standard operating procedures set by the authorities with regard to transborder movement of goods during the pandemic.

2.4.2. National pandemic-response measures

No FDI restriction measures were introduced in individual Member States' pandemic-response packages. Most measures introduced were to promote and facilitate investment, and to help businesses and investors mitigate the impact of the pandemic. Some regulatory measures were relaxed. Individual Member States also introduced stimulus packages to boost the economy, protect employment and support SMEs, supply chains and businesses, as well as to attract investment. Attracting and retaining FDI were important efforts to help stimulate economies and foster a sustainable post-pandemic recovery.

National pandemic-related measures for attracting, facilitating and retaining FDI adopted by Member States can be categorized into four main groups:

(i) **Liberalization measures** involve actions to further improve the national investment environment and open up industries for investment. They included relaxation of investment conditions and foreign equity ownership limits. For instance, some Member States relaxed policies to encourage FDI in health care. Indonesia relaxed business licensing requirements for the pharmaceutical and medical devices industries. Thailand temporarily relaxed investment conditions on affected investment activities that the Board of Investment (BOI) promoted. Viet Nam relaxed and expanded the list of businesses and industries that can have access to investment incentives.

(ii) **Facilitation measures** cover efforts to make investing in a country easier, ease administrative requirements, accelerate investment approval, provide incentives, reduce business costs and improve business efficiency. Some Member States further simplified investment procedures, introduced online or e-application systems, strengthened one-stop centres, accelerated business license approval processes and offered other support to investors (e.g. stimulus packages for investment, tax relief, tax reduction, additional investment incentives and extension of administrative compliance deadlines, such as submission of tax returns) (figure 2.2, annex 2.3). Other measures that were adopted included income subsidies for suspended workers in specific industries such as garments and footwear (Cambodia), waivers of worker levies (Singapore) and facilitation in movement of goods or supply chains of medical and essential products (customs and ports clearance) and support for existing investment (all Member States).

Most Member States adopted measures to accelerate processes for investment approval and issuance of business licenses. All made greater use of online services and granted reduction or exemption on taxes or duties. Some also reduced or waived utility and administrative fees (e.g. Brunei Darussalam, the Lao People's Democratic Republic, Malaysia, Myanmar and Viet Nam).

(iii) **Promotion measures** include provision of information and support by investment agencies. In collaboration with chambers of commerce and international business communities, some Member States organized investment events, including online seminars and webinars, to promote investment opportunities to investors. Through their investment agencies, most facilitated the issuance of appropriate documents for investors to visit their factories or investment sites in the pandemic year.

Indonesia and the Philippines provided matchmaking and support for business linkages, including sourcing of raw materials. Malaysia conducted investment promotion activities throughout 2020, including online events and webinars. Some events were organized in collaboration with chambers of commerce, banks and the international business community. The Malaysian Investment Development Agency (MIDA) collaborated with stakeholders (e.g. the Chugoku Economic Federation of Japan, the Industrial and Commercial Bank of China, the Korea Trade-Investment Promotion Agency and the Investment Promotion Agency of Qatar) to attract investment. In October 2020, MIDA officially opened its One-Stop Centre to support and facilitate investment, including permit applications for business travellers to enter the country for trade and investment purposes. In 2020, the Thai BOI organized a series of webinars, which included "Thailand: Additional Incentive for Immediate Investment in Manufacturing and Development of Medical Related Products" (targeting primarily Japanese companies), "COVID-19 Opportunities and Investment Support Measures for Medical Industry in Thailand", "COVID-19 Opportunities and Investment Support Measures for Digital Industry in Thailand" and "Thailand: A Prime Destination for the Biotech & Medical Industry" (targeting Australian investors).

All Member States maintained or extended investment agency services, and most provided special assistance services to investors. IPAs in Indonesia, Malaysia, the Philippines, Singapore and Thailand created dedicated webpages containing information on national pandemic restriction measures and a list of business support programmes administered by different ministries and agencies. In Malaysia, MIDA set up a separate webpage to address investors' enquiries about application procedures and COVID-19 implications for businesses. The Thai BOI offered a free one-hour "e-Clinic" session on general investment incentives and services provided to investors. Most ASEAN IPAs also offered investors personalized enquiries, online chat or return-call services, and online consultation.

In 2020, most Member States actively promoted FDI in health care and medical devices. For instance, Indonesia, Malaysia and Thailand stepped up efforts to attract health care-related investment. The Philippines marketed the country as a complementary investment destination for production of pandemic-related products.

(iv) **Regulatory and restrictive measures.** No restrictive measures on FDI were introduced, but regulations for health protection such as lockdowns or controlled movement of people affected FDI projects, as investors were unable to visit sites to finalize investment evaluations or conduct groundbreaking events to kickstart construction of factories and other facilities. The temporary introduction of export bans also affected the flows of essential goods in the region.

2.5. MEASURES TARGETING FDI FOR RELOCATION AND GVC RESILIENCE

In 2019–2020, some Member States also announced measures to attract MNE projects for relocation of investment or diversification of supply chain arising from the trade tensions between the United States and China and the pandemic-related supply chain disruption. Some foreign MNEs and Chinese companies had been relocating to ASEAN even before the outbreak of the pandemic, primarily because of increasing costs in China (chapter 1). In some cases, home-country measures have also played roles in encouraging diversification. Some Member States facilitated FDI diversification by providing investment incentives and offering specific support for relocation, including establishing a special task force to facilitate relocations. For instance:

Indonesia established a special task force in June 2020 to attract and help MNEs planning to relocate their investments.[9] The Government further streamlined investment processes and offered investment incentives and other supports (e.g. simplifying the business license process, assisting with factory facilities in SEZs) to improve the ease of setting up operations in the country. In June 2020, the Government reported that seven companies had confirmed their relocation to Indonesia.[10] Among them were Alpan Lighting (United States), Denso (Japan), Kenda Tire (Taiwan Province of China), LG Electronics (Republic of Korea) and Panasonic (Japan). In addition, more than 140 MNEs were subsequently reported to have plans to relocate to the country.[11]

Malaysia offered special tax incentives for companies relocating to the country through an initiative called Malaysia as Attractive Horizon for Businesses,[12] which included the following:

(i) A 0 per cent special tax rate for 10 years for new investment in manufacturing sector with capital investment of RM300 million–RM500 million

(ii) A 0 per cent special tax rate for 15 years for new investment in manufacturing sector with capital investment over RM500 million

(iii) A 100 per cent investment tax allowance for five years for companies in Malaysia that relocate overseas facilities to the country with capital investment over RM300 million. The allowance is offset against 100 per cent of statutory income for each assessment year.

These tax incentives are offered to investment projects applied between July 2020 and December 2022. Malaysia also introduced additional measures to facilitate the investment approval process and speed up implementation of approved manufacturing projects. A Project Acceleration & Coordination Unit in the MIDA was established to speed up manufacturing licence approvals for non-sensitive industry to within two working days. By July 2020, the relocation of more than 80 foreign companies to Malaysia had been reported.[13] They included Chinese and Japanese companies.

The *Philippines* provided investment incentives to attract companies to relocate to the country. Some Chinese companies and foreign companies based in China have relocated there.[14] At least nine MNEs from China have relocated production facilities to the country since 2019.[15] These were mostly in manufacturing (e.g. automotive parts and electronics components).

Other MNEs were from the United States and Taiwan Province of China. In 2020, the country facilitated more relocations, especially for companies producing electronic goods and medical products critical to the control of the pandemic.[16] Companies such as Arkray, Cytex and Yokoisada (all Japan) have relocated to the Philippines.

Thailand announced in September 2019 the provision of investment incentives to encourage foreign investors to relocate production, accelerate large-scale investment and strengthen workforce development in the country. An additional five years of a 50 per cent reduction of corporate income tax were provided to investment applications made before the end of 2020 and to projects that have in place investment worth at least $32 million by the end of 2021. Special tax benefits were offered under the Thailand Plus Package, which included additional tax deductions on certain expenses incurred from 1 January 2019 to 31 December 2020, specifically: (i) a 100 per cent additional deduction of expenses of investment in new automatic machinery and software used, to promote investment in automation; (ii) a 50 per cent additional deduction of expenses incurred with regard to salaries of skilled employees in science, technology, engineering and mathematics (STEM) to support human resources development in these areas; and (iii) a 150 per cent additional deduction of expenses incurred in connection with supporting employees for training courses that are certified by specified authorities.

The Government has set up a one-stop service to improve the ease of doing business and facilitate investment and relocation to the country. Some MNEs that have relocated their operations or expanded existing capacity in Thailand include Delta Electronics (United States), Harley-Davidson (United States), Sharp and Sony (both Japan). In addition, some Chinese companies have relocated there.

Viet Nam established a special working group in June 2020 to attract large, innovative, high-tech projects. The working group is mandated to formulate new policies to attract capital inflows from MNEs, including those that are diversifying investment locations and repositioning manufacturing facilities after the COVID-19 pandemic.[17] Some companies from China, Japan and the United States have relocated operations from China to Viet Nam. Examples include Apple, Intel, Nike, Qualcomm and Universal Alloy Corporation (all United States) and Asics, Hoya, Kyocera, Nintendo and Shin-Etsu Chemical (all Japan). Pegatron (Taiwan Province of China), a supplier to Apple, announced plans to move its R&D centre from China to Viet Nam, in addition to setting up manufacturing plants in that host country.[18]

Home-country measures

In addition to ASEAN host-country measures, some home countries of MNEs have encouraged relocation or supply chain diversification to ASEAN through policy measures and financial support. For instance, the Government of Japan provides financial incentives to Japanese MNEs to establish more resilient supply chains through diversification of manufacturing and sourcing locations to ASEAN and other Asian countries. In May 2020, it introduced two specific programmes to promote domestic and foreign investment under the Programme

for Strengthening Overseas Supply Chains.[19] The ASEAN-Japan Economic Resilience Action Plan, adopted in July 2020, further supports the strengthening of supply chain resilience centred on ASEAN.

The Programme for Strengthening Overseas Supply Chains attracted more than 340 projects from Japanese companies between July and October 2020. Of these, more than 80 had received approval and financial incentives as of December 2020 (chapter 1). Most of these firms are SMEs, and a majority of them are involved in production of health care items (e.g. masks, disinfectants, PPE), automotive parts, and electrical and electronics products.

Australia has encouraged greater resilience in supply chains in the Indo-Pacific region.[20] Under the Plan of Action to Implement the ASEAN–Australia Strategic Partnership (2020–2024), Australia committed to developing regional and global supply chain opportunities to promote inclusive growth.[21] In October 2020, the Government announced a $107 million Supply Chain Resilience Initiative to address vulnerabilities in domestic and international supply chains.[22]

2.6. RCEP AGREEMENT AND PROVISIONS RELATING TO FDI

A significant policy development, central to ASEAN, was the signing of the RCEP Agreement in November 2020. The Agreement aims to facilitate the expansion of regional trade and investment and contribute to global economic growth and development. It contains provisions that are highly relevant to cross-border investment. They include those related to trade in goods, trade in services, investment, temporary movement of natural persons, rules of origin, customs procedures and trade facilitation, trade remedies, intellectual property, e-commerce and SMEs. A summary of key elements of the main provisions of each chapter appears in annex table 2.1.

The RCEP Agreement builds on existing commitments on market access and disciplines for trade and investment under ASEAN-Plus-One FTAs, and strengthens them in some areas such as trade in services, rules of origin and e-commerce. It provides a framework for further commitments to be negotiated in future, including action plans and work programmes to realize the RCEP objectives. These ASEAN-Plus-One FTAs include ASEAN-China FTA, ASEAN-Australia-New Zealand FTA, ASEAN-Japan FTA, and the ASEAN-Republic of Korea FTA.

The investment chapter lays out the commitment of the Member States to create an enabling investment environment by providing investment protection, liberalization, promotion, and facilitation. These provisions upgrade and enhance the existing ASEAN Plus One FTAs. Key elements:

(i) Most-favoured-nation treatment clause, and commitments on the prohibition of performance requirements that go beyond the WTO TRIMS Agreement

(ii) Schedule of Reservations and Non-Conforming Measures using the negative-list approach with standstill and ratchet mechanism

(iii) Improved investment facilitation provisions, which also address investor aftercare, such as assistance in the resolution of complaints and grievances

(iv) A built-in work programme on ISDS provisions

RCEP is expected to bring important implications for FDI and value chain development within and outside the group. The RCEP Agreement contains measures in key areas such as market access, economic cooperation, and rules and disciplines (table 2.9). The specific provisions on investment could enhance investment opportunities in the long term, but the provisions related to trade in goods and services, intellectual property and e-commerce will do more to increase flows of investment in the short term by facilitating the exchange of goods and services, and by lowering transaction costs for business. While it promotes intra-RCEP trade, investment and services, non-RCEP companies can also advantage from RCEP benefits by locating and operating in the region. RCEP has the potential in helping Member States attract intraregional investment, FDI and GVC activities.

Table 2.9. RCEP Agreement: Implications for FDI

Key areas	Provisions most relevant for international investment
Investment	Consolidation of existing market access (as contained in myriad bilateral agreements) Negative-list approach for investment entry; framework for future liberalization efforts Investment facilitation (transparency and streamlining of administrative procedures for investors) Core investment protection and non-discrimination provisions (ISDS not included)
Trade in goods	Consolidation of tariff reduction or elimination schedules, single set of rules of origin (a major advancement in regional integration), facilitating trade in regional value chains Trade facilitation (rules for custom procedures, technical standards and non-tariff measures; promotion of transparency and cooperation)
Trade in services	Market access for service suppliers and enhanced transparency and rules affecting services trade Enhanced rules for cross-border supply of financial and telecommunication services to facilitate regional business operations Reduced barriers to cross-border supply of professional services and framework for recognition of professional qualifications and licenses
E-commerce	Enhanced rules governing cross-border supply and use of telecommunication services Digital trade facilitation (promotion of digital documentation, electronic signatures) No comprehensive coverage of cross-border dataflows and localization requirements, but reduced scope for new restrictions
Other rules and disciplines	Facilitation of cross-border movement of businesspeople Standardized rules to streamline intellectual property transactions Common rules on government procurement
Economic cooperation	Capacity-building and technical assistance to support implementation of the agreement Programmes to enhance the capability of SMEs to benefit from the agreement

Source: UNCTAD, *Investment Trends Monitor,* Special Edition, "RCEP Agreement a potential boost for investment in sustainable post-COVID recovery", November 2020.
Note: ISDS = investor–State dispute settlement, RCEP = Regional Comprehensive Economic Partnership, SMEs = small and medium-sized enterprises.

2.7. CONCLUSION

The investment policy environment in ASEAN continued to improve in 2018–2020 with the adoption of many regional and national investment-related measures, which were mostly favourable to FDI. An improved investment environment and regional integration played an important role in attracting high levels of FDI, culminating to an all time high inflows in 2019. However, the outbreak of the COVID-19 pandemic in 2020 halted the rising investment trend. 2020 was an unprecedented year, which saw a surge in adoption of investment measures by Member States at regional and national level to help businesses mitigate the impact of the pandemic, and to attract and retain investment.

In the period reviewed, more than 14 regional agreements or initiatives with implications for the region's investment environment were adopted. Work programmes under the AEC and ASEAN-plus-one FTA arrangements continued to be implemented. Regional agreements and declarations were adopted, including those relating to digital technologies, Industry 4.0 transformation and an ASEAN Comprehensive Recovery Framework for post-pandemic recovery. New protocols were signed to upgrade existing agreements and the RCEP Agreement, which has strong implications for future FDI flows to and GVC activities in ASEAN. All these policy developments and ongoing integration increases the attractiveness of the region for FDI.

At the national level, Member States introduced a wide range of FDI-related measures, which cover liberalization, relaxation of investment conditions, facilitation and promotion. There were a few regulatory or restrictive measures, which covered data protection requirements and cybersecurity (2019), and initial export restrictions (2020) as part of the pandemic-response measures. Most measures favourable to FDI included lowering transaction or business costs, improving the investment environment, simplifying investment processes, relaxing investment condition requirements and granting investment incentives. In supporting investors during the pandemic, Member States adopted many measures to help investors and businesses, including extension of deadlines for tax and utility payments. Investment agencies in the region provided additional investment services to investors. Member States also cooperated in not imposing export bans and agreeing to facilitate the smooth flow of supply chains and sourcing in the region, particularly for essential goods. This was crucial, as much of FDI in ASEAN is connected to GVC activities or regional production networks that involve intra- and inter-firm linkages.

In recent years, some Member States also introduced specific measures and actions to support and facilitate supply chain relocation. A key driver for investment relocation to ASEAN were rising costs in MNEs' home countries and in China. Investment relocation was accelerated by the trade tensions between the United States and China and last year, by the impact of the pandemic. The encouragement of host-country and home-country measures, in particular financial and investment incentives, provided further impetus for relocations to ASEAN.

The continued implementation of regional and national measures or agreements favourable to FDI underscores the commitment of ASEAN Member States to transforming the region into a more efficient and attractive global investment hub. While national actions to attract,

retain and facilitate FDI play a catalytic role in improving the region's attraction for cross-border investment, Member States should avoid investment incentives competition. Cooperation can be strengthened further to build more resilient supply chains and a more efficient logistics infrastructure, and to facilitate FDI in GVC activities based on the benefits of regional division of labour. A stronger institutional mechanism involving relevant host-country and home-country agencies could be considered to identify measures and to facilitate FDI flows to the region.

NOTES

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[2] *The Straits Times,* "ASEAN customs transit system involving 6 members launched, may be expanded", 30 November 2020.

[3] ASEAN Secretariat, "ASEAN Single Window" (https://asw.asean.org/about-asw).

[4] See http://investasean.asean.org and https://asean.org/asean-economic-community/asean-investment-area-aia-council/.

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[6] *WTO news,* "Joint Ministerial Statement on Investment Facilitation for Development", 5 November 2019, WT/L/1072.

[7] *WTO news,* "Negotiations on an investment facilitation agreement show high level of engagement", 9 October 2020.

[8] Malaysia, Ministry of Finance (2020). *Building the Economy Together: Short-term Economic Recovery Plan, June–December 2020* (https://penjana.treasury.gov.my/pdf/PENJANA-Booklet-En.pdf).

[9] *Jakarta Post,* "Indonesia seeks to attract firms departing China», 23 June 2020; BKPM, "BKPM Chairman Formed a Special Task Force to Attract Businesses Relocating from China", press release, 20 June 2020 (https://www3.bkpm.go.id/en/publication/press-release/readmore/2401601/59301).

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[11] *Tempo,* "Govt says 143 foreign companies plan to relocate investment to Indonesia", 16 September 2020.

[12] One of the 40 initiatives of PENJANA (section 2.4). See Malaysia, Ministry of Finance (2020), *Building the Economy Together: Short-term Economic Recovery Plan, June–December 2020* (https://penjana.treasury.gov.my/pdf/PENJANA-Booklet-En.pdf).

[13] *The Edge,* "MIDA facilitated 86 foreign companies relocation to Malaysia", 28 July 2020.

[14] *Manila Standard,* "PH woos companies moving out of China", 24 June 2020.

[15] *Manila Standard,* "9 companies relocate from China to PH – DTI", 8 October 2020.

[16] *Business Mirror,* "Government wooing 135 China-based foreign firms to relocate to PHL", 28 May 2020.

[17] *Vietnam Investment Review,* "Vietnam sets up special working group to ride wave of investment relocation", 25 May 2020.

[18] *Vietnam Investment Review,* "Nation entices many relocating companies", 30 September 2020.

[19] Ministry of Economy, Trade and Investment, Japan (2020), "Shingata coronavirus kansensho de eikyo wo ukeru jigyosho no minasama he" (in Japanese) (https://www.meti.go.jp/covid-19/pdf/pamphlet.pdf?0119), pages 41-42.

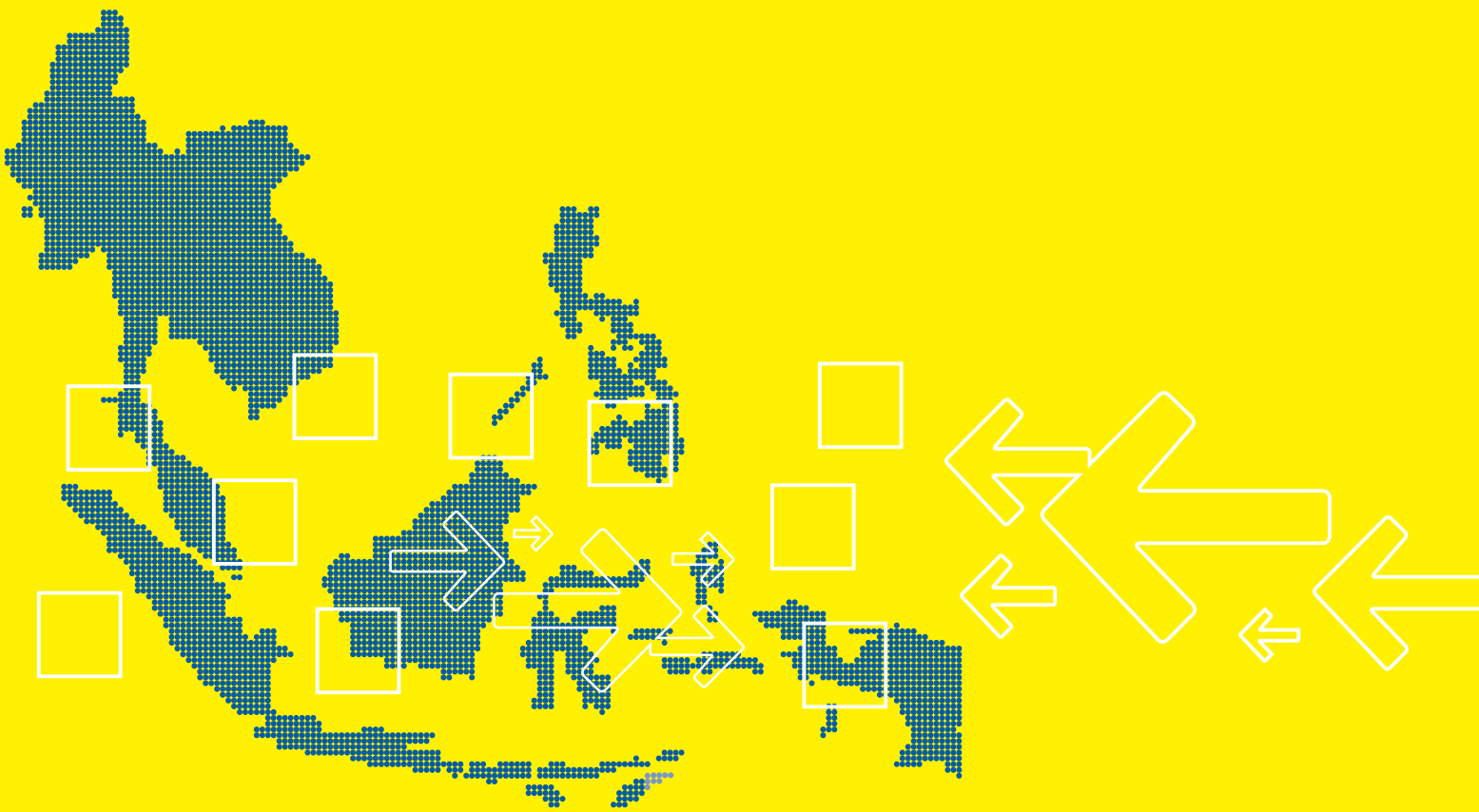
[20] *The Diplomat,* "The resilient supply chain initiative: reshaping economics through geopolitics", 10 September 2020.

[21] ASEAN Secretariat, Plan of Action to Implement the ASEAN-Australia Strategic Partnership (2020-2024) (https://asean.org/storage/2019/08/ASEAN-Australia-POA-2020-2024-FINAL.pdf).

[22] Department of Industry, Science, Energy and Resources, Australia, "Meeting our needs in times of crisis", 1 October 2020 (www.industry.gov.au/news).

PART TWO

INVESTING IN INDUSTRY 4.0



CHAPTER 3

FDI and MNEs and Industry 4.0 Transformation in ASEAN

3.1. INTRODUCTION

All ASEAN Member States recognize the importance of Industry 4.0, or the 4th Industrial Revolution, to advance economic development and industrial transformation and ensure continued effective participation in global value chains (GVCs). This has led to the introduction of Industry 4.0 national plans, adoption of regional cooperation frameworks and recognition of the role that the private sector can play in the transformation process.

Foreign investors are playing an important role in the transformation process. They produce hardware related to Industry 4.0 technologies, supply digital solutions and adopt digital technologies to upgrade their plants. Some provide Industry 4.0 skills development and training, and establish centres of excellence. Many MNEs are investing in the region to build digital infrastructure, manufacture industrial automation (IA) hardware, and operate close to clients in a vibrant manufacturing industry.

ASEAN is a manufacturing powerhouse. It is also a major recipient of FDI flows, underscoring the significance of ASEAN as a global manufacturing hub for many foreign factories. The region's division of labour, economic and industrial growth, integration, low labour cost and improving industrial ecosystem have led to significant inflows of FDI in manufacturing, from $29 billion (27 per cent of total FDI inflows) in 2010 to the peak of $62 billion (42 per cent) in 2018. Flows fell to $22 billion (16 per cent) in 2020 because of the impact of the pandemic.

To advance abilities in the manufacturing sector in the next decade and beyond, manufacturers based in ASEAN will need to deepen adoption of Industry 4.0 technologies to unlock potential, upgrade industrial capabilities and further improve efficiency and productivity – making the region a more attractive place for investment and a hub for GVCs. For this reason, Member States recently launched an Industry 4.0 transformation plan, encouraging FDI and supporting upgrading of the manufacturing industry through adoption of digital technologies (chapter 4).

This chapter provides an analysis of two key FDI issues in Industry 4.0: (i) how FDI and MNEs contribute to the Industry 4.0 transformation in ASEAN and (ii) why Industry 4.0-related companies are investing in the region. In particular, the chapter examines the roles of MNEs and FDI in enabling digital infrastructure, IA and robotics, additive manufacturing, the industrial internet of things (IIoT) and smart factories. For policies to attract FDI in Industry 4.0 related activities, see chapter 4.

3.1.1. Scope of the report

This chapter covers analysis of the role of MNEs in the application of digital technologies in manufacturing (e.g. automation, additive manufacturing, internet of things (IoT)), although such technologies are also increasingly being adopted in service industries in ASEAN (e.g. logistics and warehousing, and e-commerce). The digitalization of these industries is important to manufacturing value chains, such as for supporting efficient sourcing of raw materials and equipment, and for enhancing control of warehousing and logistics, and for sales. This report focuses on FDI and MNEs in key Industry 4.0 technology areas; it does not address investment in aspects such as cybersecurity and virtual reality technologies. Industry 4.0 can have significant implications for the economy, society and work, but these issues are beyond the scope of the report. Industry 4.0 or digital technologies are also increasingly being adopted in agriculture and mining in the region; they are also outside the scope of this report.

3.1.2. Analytical framework

Digital infrastructure (e.g. 5G and data centres) provides the necessary enabling environment for Industry 4.0 transformation, as it facilitates and accelerates the adoption of Industry 4.0 technologies. Digitalization is central for upgrading industrial technology or applying advanced manufacturing technologies such as automation, IIoT, AI and machine learning. It facilitates transformation from mechanization and from low-automation and medium-automation operation to a smart manufacturing environment. The use of an integrated network of connected, advanced digital technologies and devices (a cyberphysical environment) can lead to digitalization of manufacturing and establishment of smart factories, both indicators of Industry 4.0 transformation.

In each Industry 4.0 technology segment, FDI and MNEs play key roles in developing, supplying, adopting and installing the technologies. This report uses the framework highlighted in table 3.1 to analyse the roles of FDI and MNEs in the connected chain of Industry 4.0 technologies. Strong evidence of Industry 4.0 transformation in manufacturing is the establishment of smart factories and the deployment of digital twin technology, which integrate a portfolio of Industry 4.0 technologies to support advanced digitalization of manufacturing. *WIR2017* and *WIR2020* also provide key elements for an analytical framework.

Table 3.1. Industry 4.0: selected value chain activities

Technology	Industry 4.0 connection
Digital infrastructure	Key enabler for the application of digital technology and connectivity (e.g. 5G network, broadband capacity, data centres, cloud facilities and cybersecurity)
Industrial automation and robots	Important foundation for applying more advanced IA and digital technologies (e.g. IIoT and smart factories)
Additive manufacturing	Enhances manufacturing with 3D printing technology, including for efficient production of complex parts and components
IIoT	Enables digital connectivity, machines communicating with machines, support data analytics, machine learning, AI, preventive maintenance, and real-time and remote control and management of production
Smart factories	Digitalized manufacturing environments where machines and devices communicate constantly, collecting, sharing and analysing data to achieve optimum production efficiency; involves adoption of smart manufacturing technologies, IIoT, additive manufacturing, advanced automation and digital twins

Source: ASEAN Investment Report 2020-2021 research, based on industry reports.

3.2. FDI AND MNEs IN INDUSTRY 4.0

FDI in Industry 4.0-related activities in ASEAN is expected to increase in the next decade. The values of announced greenfield investment in information and communication are increasing (section 3.3.1), and more than 12 per cent of all greenfield investment in ASEAN by value in the last decade is in IA-related activities. MNEs are investing across the Industry 4.0 technology spectrum and are expanding operations in the region. This includes upgrading digital technologies or manufacturing systems in factories. These MNEs include (i) digital infrastructure and telecommunication corporations (section 3.3), (ii) IA and robotic firms (section 3.4), (iii) additive manufacturing companies (section 3.5) and advanced digital technology and smart factory solution players (section 3.6).

FDI in Industry 4.0 is taking place through different business functions. They include the following key activities:

(i) Setting up supply bases or subsidiaries for sales and distribution of automation, robots, additive manufacturing (AM) and other advanced manufacturing solutions

(ii) Investment in upgrading IA and digital technologies in own factories (e.g. application of IIoT and smart factories)

(iii) Manufacturing IA products, parts and equipment and offering customized advanced manufacturing software solutions

(iv) Providing Industry 4.0 skills development and training (chapter 4)

(v) Establishing R&D facilities, technology hubs and centres of excellence

Most investments are concentrated in the major industrialized ASEAN Member States (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam). Those that are more industrialized and that have an efficient manufacturing ecosystem, a large and growing market, and digital infrastructure support have received greater investment in Industry 4.0-related activities.

Most IA is in the electronics and automotive industries. They are key target areas for FDI and MNE activities. Other industries (e.g. metal and machinery and food and beverages) are also witnessing deployment of automation and application of advanced digital technology solutions (e.g. IIoT). In digital infrastructure, with the roll-out of 5G licenses across ASEAN, many telecommunication MNEs are participating in 5G infrastructure development. Digital technologies are also increasingly being adopted in non-manufacturing industries *(AIR 2019).*

Many factors motivate MNEs to invest in Industry 4.0 activities in ASEAN. Key drivers include the rapid growth in demand and the market potential for hardware and technology solutions. Increasing automation, digitalization of manufacturing, delivery of 5G networks and strong growth in other digital economy industries (e.g. e-commerce and fintech) are pushing demand for digital technologies. More MNEs and local companies are adopting or planning to adopt Industry 4.0 technologies. These developments are creating investment opportunities across segments of Industry 4.0 value chains (e.g. from digital infrastructure and automation to digitalization, including in R&D, technology hubs and centres of excellence). A dynamic and vibrant regional manufacturing industry is influencing MNEs to establish and expand operations to be near to markets and customers. ASEAN's economic integration through the ASEAN Economic Community (AEC) is providing scope for MNEs to scale up business operations. Strong commitment to and policy support for Industry 4.0 transformation in ASEAN Member States is another major reason.

3.3. INVESTMENT IN DIGITAL INFRASTRUCTURE IN ASEAN

Digital infrastructure such as 5G networks and data centres provides the backbone for Industry 4.0. They improve the efficiency of the digital environment, enable faster connectivity, meet huge data information requirements, facilitate rapid data processing and offer large storage capacity. Such an environment is imperative for the application of Industry 4.0 technologies such as advanced automation, AI, data analytics, the IoT, smart factories and smart cities. Attracting investment in digital infrastructure, including cloud facilities, is essential and is actively promoted by governments in ASEAN.

Digital infrastructure will accelerate digitalization and Industry 4.0 transformation in ASEAN. Enhanced connectivity and application of Industry 4.0 technologies are expected to generate $140–150 billion in additional revenue potential across key industries (agriculture, services and manufacturing) for ASEAN by 2025 (AT Kearney, 2019). 5G alone is expected to unlock 40 to 50 per cent of this additional revenue, and the manufacturing industry will be a major beneficiary.

Most countries in ASEAN have rolled out 5G licenses to operators (mostly local telecommunication companies), which in turn are working with foreign MNE vendors to supply equipment, solutions and construction of core 5G infrastructure. Their participation mostly takes the form of non-equity arrangements through project contracts. Investment in digital infrastructure in ASEAN is growing rapidly, with delivery or trials of 5G technology in 2020

in a few targeted ASEAN cities. In 2020, Globe Telecom (Philippines) started deploying 5G technology in Metro Manila,[1] Viettel conducted a 5G trial roll-out in three districts in Hanoi (Viet Nam),[2] StarHub (Singapore) launched a six-month trial 5G network in Singapore,[3] and Thai mobile operators Advanced Info Service (AIS) and True Corporation launched 5G networks, starting with hospitals across Thailand.[4] The launch of national Industry 4.0 plans in ASEAN is driving up demand for digital infrastructure.

The region has received growing attention for investment in data centres in recent years. Key drivers include rapid rising demand from industries and consumers, the fast-growing digital economy (e-commerce, as well as travel, media, entertainment and fintech), and the improving digital ecosystem. The COVID-19 pandemic further accelerated the pace of digitalization, which in turn increases demand for more data centres and cloud facilities to support automation, further internet growth and digitalization of value chains (e.g. digitalization of manufacturing and digital services) (box 3.1).

Box 3.1. Effects of the pandemic on data centre and cloud market in ASEAN

The COVID-19 pandemic accelerated digitalization, intensified e-commerce, and increased the use of remote working and other digital activities in ASEAN. Consumers, manufacturers and other businesses in a wide range of industries demanded more digital, internet, cloud and data centre facilities. Some industries experienced significant increases in demand for digital operation and services. They included manufacturing, online retail, entertainment, communication, education and health care.

Digitalization of manufacturing

During the lockdown period between January and August 2020, manufacturing firms in Singapore embarked on more than 1 300 projects to upgrade and transform their businesses through Enterprise Singapore. This represents a 65 per cent increase from the same period in 2019. The main areas of transformation involved technology deployment and automation, remote monitoring and digitalization solutions.[a]

E-commerce

Online shopping in ASEAN increased exponentially, based on traffic on the e-commerce platforms of Shopee (Singapore) and Lazada (owned by Alibaba (China)). Shopee saw e-commerce orders rise by 111 per cent to 430 million in the first quarter of 2020, as compared with 203 million in the same period in 2019.[b] Malaysian cloud-based grocery service MyGroser saw a 1 000 per cent increase in online demand in the early phase of the lockdown under Malaysia's Movement Control Order.[c] In Indonesia, the pandemic has accelerated digital adoption and is changing the business landscape, requiring many businesses, including manufacturing, to adapt to evolving business environment and consumer preferences towards online system.[d] PT Semen Indonesia, a state-owned cement manufacturer, strengthened its digital sales platform to overcome challenges arising from the impact of the pandemic. It partnered with building material stores through its marketing platform (AksesToko.id) to encourage online transactions. It also launched an official online store in Tokopedia's (an Indonesian unicorn) platform. The pandemic has led to the growth of internet demand from businesses and households and bolstered the rise of the country's digital economy, which has implications on demand for data centre and cloud computing facilities. In 2020 alone, there was a 50 per cent increase in the number of digital services user and by 2025, the Indonesian digital economy is expected to worth more than $120 billion, nearly triple of its current value.[e]

/...

Box 3.1. Effects of the pandemic on data centre and cloud market in ASEAN (Concluded)

Remote working and education

The pandemic forced many companies and employees to adapt to remote working and telecommuting in ASEAN. Demand for services like Zoom and other communication technology soared. In Indonesia, for example, demand for work-from-home digital applications rose in the first half of 2020. Zoom, Microsoft Teams, and other office software such as Google Suite and Cisco WebEx supported more than 3 300 Indonesian companies across Jakarta alone in implementing work-from-home policies.[f] PT Telekomunikasi Selular saw more than a 443 per cent increase in usage of online meeting applications such as Zoom, Microsoft Teams and Telkomsel CloudX. A surge in the use of e-learning applications, such as Ruangguru, universities' e-learning centres and Google Classroom led to a significant rise in broadband traffic. All three e-learning applications witnessed more than 5 400 per cent increases in usage.[g] In Singapore, more than 400 schools have been using Zoom facilities since the pandemic started.

Health care (telemedicine)

The pandemic has also accelerated the use of e-health (e.g. telemedicine). Doctor Anywhere (Singapore) experienced nearly fourfold increase in business and a ninefold increase in consultations for chronic medication refills during the pandemic. The company saw a 41 per cent increase in sign-ups for video consultation service in January–March 2020 and an 89 per cent increase in calls made by Great Eastern insurance customers.[h] In Indonesia, Alodokter saw the usage of its telemedicine platform rise to 32 million visitors in March 2020 from 20 million before the pandemic. GrabHealth, a joint venture between Grab (Singapore) and Ping An Good Doctor (China), saw daily consultations on COVID nearly double to 10 000 in March 2020 as compared with between 5 000 and 6 000 a day before the pandemic.

Online video streaming and digital entertainment

Searches for video subscription services also increased significantly in the region in 2020, as compared with 2016 levels. For instance, searches were 11 times higher in Indonesia, 8 times higher in Thailand and 12 times higher in Viet Nam (Google, Temasek and Bain, 2020). Video streaming in the region has also risen during the pandemic. Streaming uptake rose the fastest in Indonesia, at 66 per cent, followed by Viet Nam at 59 per cent and Malaysia at 58 per cent.[i]

E-payments and digital wallet apps

The pandemic led to an increase in e-wallet transactions, from an average of 18 per cent before COVID-19 to 25 per cent post-pandemic in the six major ASEAN digital marketsj (Google, Temasek and Bain, 2020).

Source: Media reports.

[a] *The Straits Times*, "More manufacturers transform themselves digitally amid pandemic", 18 October 2020.

[b] *Nikkei Asia*, "Coronavirus pandemic fuels Asia e-commerce boom", 31 May 2020.

[c] *w.media*, "Coronavirus pandemic creates lucrative cloud application investment opportunities for Asia Pacific", 13 May 2020.

[d] *World Today News, "The digital adaptation of Indonesian society is considered fast during the Covid-19 pandemic"*, 12 September 2020.

[e] JLL, "Indonesia's potential for data center real estate market", 30 April 2021(https://www.jll.co.id/en/trends-and-insights/research/indonesias-potential-for-data-center-real-estate-market).

[f] ASEAN-Australia Strategic Youth Partnership, "Surviving Covid-19: Digital workplaces for Indonesian enterprises", 13 August 2020.

[g] *Jakarta Post*, "Telkomsel reports 16% jump in broadband traffic as people follow physical distancing rules", 7 April 2020.

[h] *KrAsia*, "Covid-19 and the rise of the healthcare apps", 3 July 2020.

[i] *BusinessWire*, "57 percent of Southeast Asian viewers are now streaming more OTT video content because of COVID-19, according to new research from the Trade Desk", 7 December 2020.

[j] Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam.

Digital infrastructure will increase the efficiency, capacity and competitiveness of the manufacturing industry in the region. It enables faster connectivity, lower latency and stronger IT processing capacity, which will enhance end-to-end digitalization of manufacturing. It permits efficient deployment of cyber-machine interconnections and integration of Industry 4.0 technologies (e.g. the IIoT, robots, big data, AI) to support remote real-time decision-making, production control and preventive maintenance. It will also enable greater digitalization of supply chains, empowering an efficient interconnection between production and manufacturing services (e.g. monitoring inventories, tracking deliveries and enabling the application of smart logistics and warehousing solutions).

3.3.1. 5G investment and MNEs

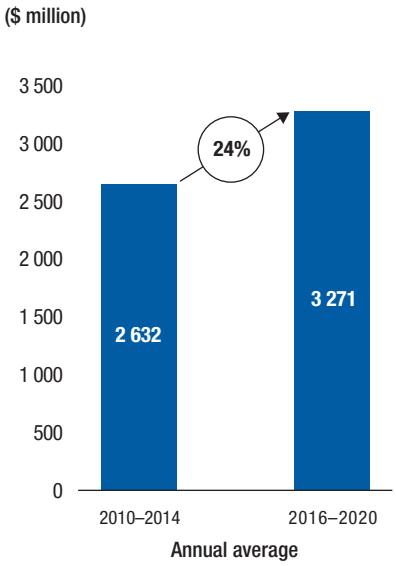
The major roll-out of 5G networks in most ASEAN Member States is scheduled for 2021. The upgrading of telecommunication infrastructure with 5G technology (stand-alone and non-stand-alone) will unlock new digital capabilities and opportunities, including for investment. It will accelerate the adoption of Industry 4.0 technologies. Aside from manufacturing, other areas of the digital economy (e.g. e-commerce, cloud gaming, online health care, smart cities) are expected to also benefit and scale up rapidly with faster digital connectivity.

The uptake of 5G technology in ASEAN is expected to grow significantly, from zero subscribers in 2020 to more than 225 million by 2025 (AT Kearney, 2019). Indonesia is forecasted to have more than 100 million subscribers, and penetration rates in the other industrialized ASEAN countries will grow rapidly. For instance, Singapore is expected to witness a penetration rate of 50 per cent, with Malaysia, Thailand and Viet Nam between 25 and 40 per cent by 2025.

(a) 5G investment

The investment needs for 5G infrastructure in ASEAN are significant, estimated at about $14 billion in annual capital expenditure in 2020–2025, on the basis of non-standalone infrastructure development (i.e. by upgrading telecommunication facilities, networks and equipment to meet 5G requirements) (A.T. Kearney, 2019). Investment in information and communication segment has been increasing. For instance, the value of announced greenfield investment projects in this segment in ASEAN rose from an annual average of $2.6 billion in 2010–2014 to $3.3 billion in 2015–2019 – a 24 per cent increase (figure 3.1). With 5G roll-out and growth in demand for cloud facilities, investment in information and communication infrastructure in the region is expected to rise rapidly through 2025.

Figure 3.1. Announced greenfield investment projects in information and communication in ASEAN, 2010–2019 (Millions of dollars)



Source: UNCTAD.

(b) MNEs in 5G development

European and Asian (e.g. ASEAN and Chinese) telecommunication MNEs are active contractors or investors in ASEAN's 5G infrastructure development. These MNEs won contracts from national operators to supply equipment, network devices and technology solutions and to construct core 5G networks (table 3.2).

Table 3.2. MNEs involvement in ASEAN 5G roll-out

Country	5G technology suppliers
Brunei Darussalam	The Government launched in April 2021 a 5G pilot project, which involved foreign telecommunication infrastructure companies such as Huawei (China).
Cambodia	The Government signed an agreement in 2019 with Huawei (China) to build 5G network. Viettel (Viet Nam) has tested 5G deployment in Cambodia in 2019.
Indonesia	Local cellular operators have been conducting 5G network trials since 2017, but most of them are directed at industrial rather than commercial users.[a] Some telecommunication MNEs such as Axiata XL (Malaysia) is upgrading fibre network to prepare for 5G. It signed an agreement with Huawei (China) to construct core 5G network in Jakarta, commencing in 2019. In August 2020, XL Axiata awarded Ericsson (Sweden) a contract to deploy cloud packet and network functions virtualization infrastructure technologies in East Indonesia. ZTE (China), a telecommunication equipment manufacturer, was selected as the vendor for Indonesian 5G operators (Smartfren and Telkom Indonesia). It partners with Smartfren since 2019 to demonstrate 5G applications in the manufacturing industry. Nokia (Finland) was awarded contract for multi-protocol label switching network by Indosat Ooredoo (Qatar) in Indonesia. The contract included support for the 4G/LTE network and prepare for future 5G mobile services.

Table 3.2. MNEs involvement in ASEAN 5G roll-out (Concluded)

Country	5G technology suppliers
Lao People's Democratic Republic	Lao Telecom (a joint venture between the Government of Lao People's Democratic Republic and Singapore-based Shenington Investments, a subsidiary of Thailand based satellite operator and communications provider Thaicom) launched its 5G network in September 2020. Lao Telecom and Unitel (a subsidiary of Viettel (Viet Nam)) have been involved with 5G trials since 2019.
Malaysia	Preparation to roll-out 5G in 2021 is ongoing.[b] This includes allocation of spectrum for the deployment of 5G connectivity. The Government is setting a $3.7 billion funding for the 5G roll-out for the next 10 years. Maxis, a major local telecommunication operator, contracted Huawei (China) in 2019 to supply 5G hardware, services and technology solutions. Huawei and Ericsson (Sweden) are 5G vendors for Axiata Group, another major local telecommunication operator. Huawei is also building its first ASEAN 5G security centre in Malaysia[c] and collaborated with Maxis in 2020 to develop the country's first TechCity to build seamless digital communities. Nokia (Finland) and U Mobile deployed single radio access advanced networks to expand services and collaborate on 5G live network trial in Malaysia.
Myanmar	A few major telecommunication companies are partnering with technology providers for feasibility of 5G services. Ooredoo (Qatar) is partnering with ZTE (China) for 5G development. Viettel (Viet Nam) tested its 5G network in 2019. Telenor (Norway) in partnership with Ericsson (Sweden) successfully tested in 2018 IoT technology application on its network.
Philippines	The Philippines started rolling out 5G technology in 2019 through two local telecommunication operators (i.e. Globe Telecommunication and Smart Telecommunication). Both companies partnered with Huawei (China) for equipment supply for 5G roll-out. Smart is also partnering with Ericsson (Sweden). Huawei, Ericsson and Nokia (Finland) are 5G vendors to Globe Telecommunication, another major local player. In December 2020, Nokia signed a 5G memorandum of understanding with the NOW Group. The collaboration covers 5G standalone network and 5G use cases. PLDT announced in July 2020 to launch 5G mobile service using equipment to be supplied by Huawei and Ericsson.
Singapore	Singapore Telecommunication and a joint venture between StarHub and M1 were awarded contracts to build the country's 5G networks. Singapore Telecommunication works with Ericsson (Sweden), while StarHub and M1 have chosen Nokia (Finland) to build standalone core 5G infrastructure. The Singaporean awardees will also collaborate with other MNEs such as Huawei and ZTE (both China) in the 5G delivery.[d]
Thailand	Local Thai telecommunication companies are partnering with MNEs in 5G roll-out. True Corporation is working with Ericsson (Sweden) and Nokia (Finland). Total Access Communication (DTAC), part of Telenor (Norway), is partnering with Nokia to deploy 5G and 4G equipment in selected areas in Thailand. Ericsson announced in January 2021 collaboration with DTAC on 5G network. Huawei (China), Ericsson (Sweden), Nokia (Finland), Samsung (Republic of Korea) and ZTE (China) have tendered for AIS contract to deliver core 5G roll-out. ZTE partners with True Corporation in 2020 to build a commercial 5G network in Thailand. AIS has a partnership with Huawei to sell 5G smart phones in the country.
Viet Nam	The Government awarded in 2019 the country's first trial 5G license to Viettel, a major local telecommunication company. Viettel worked with Ericsson (Sweden) and Nokia (Finland) in the trial, deploying technologies from the two companies and using base stations manufactured in Viet Nam.[e] In May 2019, Viettel and Ericsson demonstrated the first 5G connection in Viet Nam, while Nokia supplied end-to-end solution including 5G cloud-based core, radio, and transmission in Ho Chi Minh City.

Sources: Company press releases and media reports.
[a] *Jakarta Post,* "Indonesians can expect 5G connectivity in 2022: Association", 28 November 2019.
[b] *Nikkei Asia,* "Malaysia fast-forwards 5G rollout to end of this year", 19 February 2021 and *The Edge,* "Tech: Recognizing the elements required to rollout 5G in Malaysia", 12 August 2020.
[c] *ASEAN Today,* "Malaysia and Huawei open Southeast Asia's first cybersecurity center to support 5G growth", 26 February 2021.
[d] *ZDNet,* "Singapore kickstarts 5G era, likely to run on Nokia, Ericsson networks", 24 June 2020.
[e] *CIO,* "How will 5G affect businesses in Southeast Asia?", 3 December 2019.

5G players in ASEAN can be grouped into four categories depending on the role they play in the 5G infrastructure value chain (table 3.3). Some telecommunication MNEs participate in multiple segments of the chain because of their end-to-end business model. These MNEs participate in 5G infrastructure development, provide 5G ready mobile phones and also supply equipment and components for the construction of networks.

Table 3.3. Types of 5G players in ASEAN

Type	Activity	Examples
Equipment and component suppliers	Production of 5G network equipment, 5G chips for 5G handsets and related equipment	Huawei (China) Mediatek (Taiwan Province of China) Qualcomm (United States) Samsung (Republic of Korea
Mobile phone company	Involve with 5G infrastructure and provides handsets that are 5G ready, with built-in 5G receptors and transmitters	Apple (United States) Ericsson (Sweden) Samsung (Republic of Korea) Nokia (Finland) ZTE (China)
Technology solution providers	Involve with 5G technology solutions and communication software	AT&T (United States) Deutsche Telekom (Germany) Ericsson (Sweden) Huawei (China) Nokia (Finland)
Telecommunication infrastructure company	Traditional telecommunication companies that provide fixed and mobile phone infrastructure, including internet connection	Axiata (Malaysia) Ericsson (Sweden) Huawei (China) Nokia (Finland) NTT (Japan) Singtel (Singapore)

Source: ASEAN Investment Report 2020–2021 research, based on industry reports and media.

A few major telecommunication MNEs are involved with multiple 5G development contracts with various operators in the same host country and in multiple ASEAN Member States. These MNEs include Ericsson (Sweden), Huawei (China), Nokia (Finland) and ZTE (China). Aside from major global telecommunication MNEs, regional telecommunication companies (AIR 2018) are emerging as important investors in 5G development in neighbouring countries. These companies include Axiata (Malaysia), with 5G projects in Cambodia and Indonesia; Singapore Telecommunication (Singtel) (Singapore), with involvement in the Philippines through Globe Telecom (Philippines); Indonesia through Telkomsel (Indonesia) and through AIS in Thailand; and Viettel (Viet Nam) is involved with 5G projects in Cambodia, the Lao People's Democratic Republic and Myanmar.

3.3.2. Data centres and cloud facilities

The data centre market in ASEAN is expected to grow significantly in the next few years, at 13 per cent compound annual growth rate (CAGR) by 2024 – exceeding that of 6.4 per cent in North America and 12.2 per cent in Asia-Pacific (Cushman and Wakefield, 2019). In absolute terms, the industry is projected to grow from about $1.9 billion in 2019 to more than $3.5 billion in 2024. More than 40 per cent of data centres in the region are foreign owned or involve joint ventures.

Investment in data centres and cloud services has been increasing rapidly in ASEAN in recent years. There were more than 295 data centres in the region in 2020, with most concentrated in Singapore, Indonesia and Malaysia (table 3.4). These three Member States accounted for

70 per cent of data centres in ASEAN. In perspective, ASEAN accounts for 23 per cent of data centres in the member countries of the Regional Comprehensive Economic Partnership (RCEP), with China hosting the largest number (413), followed by Australia (273) and Japan (203).

Brunei Darussalam had one data centre in 2020 owned by Elmec (Italy) as well as data centres owned by a local company but managed by Level 3 Communications (United States).

Cambodia has four data centres, and one involved investment from SeaTel (Singapore).

Indonesia has the second highest number of data centres in ASEAN, after Singapore. More than 22 centres are owned by foreign companies. Investment in data centres is rising with increasing presence from MNEs. Some have established multiple data centres. For instance, NTT (Japan) has three and Alibaba (China) is building a third one in the host country.

Table 3.4. Data centres in ASEAN, 2020 (Number and per cent)

Country	Data centres (Number)	Foreign owned (%)	Internet penetration (%)	CAGR 2019–2024 (%)	Examples
Brunei Darussalam	2	50	95	..	One is owned by Elmec (Italy) and another by UNN (a local company, with facilities managed by Level 3 Communications (United States)).
Cambodia	4	25	58	..	One data centre is owned by Southeast Asia Telecommunication (Singapore).
Indonesia	62	36	74	21.8 (Jakarta)	11 of the 22 foreign-owned data centres are headquartered in Singapore.
Lao People's Democratic Republic	1	100	48	..	The data centre is owned by Global Digital Management Solutions (Singapore).
Malaysia	44	27	84	12.9 (Kuala Lumpur)	Foreign investors are from Australia, China, Hong Kong (China), Japan, Singapore and the United States.
Myanmar	6	83	43	..	Most data centres are owned by ASEAN companies: Singapore (3), Thailand (1), and a joint venture between a Singapore firm and a local company.
Philippines	28	29	67	14.2 (Manila)	NTT (Japan) has multiple data centres. Other investors are from Australia, Singapore and the United States.
Singapore	100	55	90	5.1	About 53 per cent of the at least 55 foreign-owned data centres are United States companies. Other major investors are from Australia, China, Europe, Indonesia and Japan.
Thailand	29	17	75	12.5 (Bangkok)	Japanese companies such as NTT and Fujitsu are active investors. Other investors include companies from Singapore (e.g. ST Telemedia) and the United States.
Viet Nam	20	60	70	14.5 (Hanoi	Many data centres are established through joint ventures with local companies. Foreign MNEs such as NTT and KDDI Telehouse (both Japan) also directly own data centres.
ASEAN	**295**	**41**	**..**	**12.9**	

Sources: Based on Cloudscene (data extracted on 1 March 2021), We are Social, Cushman and Wakefield (2019), industry reports and media.
Note: Internet penetration is as of January 2021 and based on percentage of population. Percentage of foreign-owned data centres in ASEAN is based on weighted average. RCEP-15 host more than 1,300 centres in 2020.

The cloud computing market in *Indonesia* is expected to exceed $1 billion in 2020 with data centre market to grow at 21.8 per cent (in Jakarta) CAGR in 2024. Increasing demand from rapid internet growth, social media and industrial users is driving the upward trend. In 2018–2019, Indonesia added more than 20 million new social media users, and about 95 per cent mobile users watch online videos, and over 60 per cent of the population now perform banking services via smartphones.[5] Increasing data centre demand for digital transformation from businesses is also contributing to growing cloud market.

Firms in other industries such as e-commerce, transport and logistics, media, and finance are demanding more cloud services and data centre facilities. The plan for development of smart cities also provide a major growth impetus for data centres. The country's data security law requires data centres and data residency to be in Indonesia. These market development and rising demands present major opportunities to data centre and cloud investors.

Foreign data centre and cloud providers in the country are mainly from China, Japan, the United States and Singapore. As of 2020, Indonesia has more than 68 cloud service providers. Some foreign providers include Amazon Web Services (AWS) (United States), Alibaba Cloud (China), China Telecom (China), Google Cloud (United States) and Microsoft (United States).

Major global data centre companies (e.g. Equinix and Zenlayer (both United States)) and Acclivis Technologies (a subsidiary of Hong Kong, China headquartered CITIC Telecom International)) have facilities in the host country. NTT (Japan) have also established data centres to cater to Japanese firms and other companies. Regional players from Singapore (Space DC and Keppel DC) and Malaysia (Finexus Group) have established data centres in Indonesia. Foreign MNEs also contribute to the development of data centres and cloud industry through providing technology and equipment to locally owned data centres.

The *Lao People's Democratic Republic* has a small population and a low internet penetration (48 per cent). As of 2020, there is only one data centre, which is foreign owned. The market condition and the lack of digital infrastructure (e.g. 5G network) hampers investment in cloud and data centre.

Malaysia has more than 44 data centres, and at least 27 per cent are foreign owned. Most of the locally owned data centres involve foreign partnership. Malaysia's data centre market size is likely to reach revenues of over $800 million by 2025, up from $500 million in 2020.[6] As of 2020, Malaysia had about 80 cloud service providers, and many of them are MNEs.

Increasing demand for hyperscale cloud services, increasing digitalization in industries and government policies favouring digitalization are the primary drivers for the growth of data centres and cloud services. Demand for data storage and managed hosting services in Malaysia is expected to grow rapidly because of the extensive internet penetration (84 per cent), the focus on cybersecurity and data privacy, and the demand for co-location from cloud service providers.

The national Industry 4.0 plan encourages adoption of the IoT, sensor technology, AI, machine learning, mobile connectivity, robotics and 3D printing. Application of these technologies and

smart cities development projects increase demand for cloud services and data centres. The Government is also focusing on improving readiness to support hyperscale data centres by improving the country's telecommunication and network infrastructure and rolling out 5G.

Major MNEs providing data centres and cloud services are mostly from China, Japan and the United States. Among Chinese cloud companies in Malaysia, Huawei and Alibaba have multiple data centres, Tencent is establishing one with a local player and Bridge Data, a subsidiary of the China Data Group, has a data centre operation. Japanese MNEs may have multiple facilities; for example, NTT and Hitachi in their joint venture with Sunway (Malaysia). Two major MNEs from the United States (AWS and Zenlayer) and one from Singapore (Keppel DC) have also established data centres in the country. Other cloud service providers in Malaysia include StarHub and ViewQwest (both Singapore), China Mobile, DTAC (Thailand), Google Cloud (United States), Tata Communication (India) and Telstra (Australia).

Some Malaysian data centre companies have become regional players, with operations mostly expanded to Indonesia, the Philippines, Singapore, Thailand and Viet Nam. For instance, AIMS, Axiata, CSF Group, Finexus and Strateq have investments in other ASEAN countries. Malaysian companies have also developed local data centres in partnership with major MNEs. These companies include VADS (a joint venture between IBM Global Network Services (United States) and Telekom Malaysia) and Hitachi-Sunway Information Systems (a partnership between Hitachi and Sunway Group (Malaysia)).

Myanmar has six data centres, most owned by ASEAN companies. They include three from Singapore, one from Thailand, a joint venture between a Singapore company and a local enterprise, and a local company. There are at least 12 cloud service providers as of 2020. The top five account for 64 per cent of the cloud industry in terms of numbers of points-of-presence (PoPs). Four are foreign suppliers: Ooredoo (Qatar), Campana (Singapore), NTT Communication (Japan) and Zenlayer (United States). Other MNEs involved in cloud facilities include China Unicom, SingTel (Singapore) and Telenor (Norway).[7]

The *Philippines* has more than 28 data centres, 9 of them foreign owned. Locally owned data centres are also involved in partnerships with foreign MNEs. The Philippine data centre market is projected to grow at 14.2 per cent (CAGR) in 2019–2024. Strong demand from IT-business process outsourcing (BPO) activities (AIR 2018, 2019), e-commerce, other industries are driving data centre investment in the country. Some 850 registered BPO companies, many of them MNEs, are adding to the demand for data centres and cloud services. Another growth driver is rising internet penetration. In 2019 about 65 per cent of the population accessed the internet from mobile phones, and by 2025 this figure is projected to exceed 75 per cent. In 2020, 67 per cent of the population used the internet, and by 2025 this figure is expected to grow to 77 per cent. The Data Privacy Act of 2012 protects all forms of information and covers companies involved in the processing of personal information, including those using equipment located in the Philippines or having a physical presence in the country. This data residency concept requires cloud service providers to localize their data centres in the Philippines.

Many MNEs have developed and owned data centres and cloud services in the Philippines. They include AWS (United States), NTT Communications (Japan) and Zenlayer (United States). Other foreign players include Continent 8 Technologies (United Kingdom), DataOne (Singapore) and Telstra (Australia). The two biggest local players are telecommunication companies: PLDT (with 10 data centres) and Globe Telecom (with 4). These two have also formed partnerships with foreign MNEs to develop data centres. Other foreign companies providing cloud services include China Telecom (China), PCCW (Hong Kong, China), StarHub (Singapore) and Tata Communication (India).

Singapore is one of the fastest-growing data centre markets in ASEAN. It has more than 100 data centres and some 55 are foreign owned. Investment in data centres and cloud computing is expected to continue to grow because of increasing demand from enterprises and industries. Investment in public cloud services alone is expected to grow at 20 per cent CAGR, from $1.5 billion in 2018 to $3.6 billion in 2023. This would represent 0.4 per cent of the country's GDP, which is one of the largest ratios of public cloud services spending to GDP.[8]

The country's efficient digital infrastructure and connectivity is an important determinant of FDI in data centres. Singapore is the end point for 24 submarine cables and is one of the world's major cloud-connected locations. Its thriving digital economy, its position as a regional headquarters for many MNEs and government policy favouring Industry 4.0 transformation are helping the country attract many data centres and cloud companies.

Major foreign investors in data centres are from China, Europe, Japan and the United States. As of 2020, there were at least 450 cloud service providers (local and foreign) in Singapore.[9] Global leaders in cloud computing from the United States such as AWS, Google Cloud, Microsoft Azure and IBM Cloud are in Singapore, as are video communication provider Zoom and data centre operators such as Zenlayer and Digital Realty. Facebook (United States) is investing more than $1 billion in data centre facilities in the country, which are expected to open in 2022. Equinix (United States), a global realty MNE that specializes in data centres, has five in Singapore and is providing co-location facilities to other foreign-owned data centres such as those of ABN Amro (Netherlands), China Telecom (China), Cisco (United States), DigitalOcean (United States) and ReadySpace (Singapore). Chinese MNEs (Baidu, Huawei and Tencent) have data centres and cloud operations in the country. Alibaba is establishing a research laboratory in Singapore, part of the company's new $15 billion global research programme. Japanese companies KDDI, NTT, NEC and Fujitsu have also set up data centres. Data centre and cloud companies from other countries such as Finland, France, Germany, the Netherlands, the United Kingdom and ASEAN (Indonesia and Malaysia) also have a presence in Singapore.

Locally owned data centres have partnership arrangements with foreign MNEs. For instance, M1 Ltd. partners with VMWare (United States) for cybersecurity and with Huawei (China) for next-generation, software-defined, networking technology. Sparkstation has collaboration arrangements with Akamai (United States), Google Cloud (United States) and PCCW (Hong Kong, China). Racks Central partners with Equinix (United States) on a cloud exchange fabric platform. In April 2020, Keppel Data Centres (Keppel DC) signed separate memorandums of

understanding with Toll Group (Japan) and Royal Vopak (Netherlands) to study the feasibility of developing a floating data centre park and liquefied natural gas-to-power infrastructure in Singapore.

Singapore data centre companies are internationalizing their operations, including to other ASEAN Member States. The Government supports the country's data centre industry by promoting FDI and encouraging participation by local companies such as ST Telemedia, Singtel and Keppel. These local companies have expanded data centre businesses in ASEAN and further afield.

The data centre and cloud market in *Thailand,* which is at a nascent stage, was about a $1 billion industry in 2020. The data centre market is forecasted to grow at 26 per cent CAGR in 2019–2025,[10] thanks to increasing demand from financial institutions, the automotive industry, technology content providers, start-ups and retail businesses as well as digital transformation of businesses in the post-pandemic recovery. Enterprise digitalization, such as the application of big data, AI, and the IIoT, and government digitalization policy support are expected to further drive growth.

There were at least 29 data centres and 53 cloud service providers in Thailand as of 2020. Most data centres are owned by local companies; there are more foreign companies in cloud segment. Four of the top five cloud providers in terms of numbers of points-of-presence are foreign companies.[11] They are TeleData Center (Viet Nam), StarHub (Singapore), China Telecom and Console Connect (Hong Kong, China), in that order. Other cloud providers include Anexia (United States), Campana (Singapore), PCCW (Hong Kong, China), Tata Communication (India), and Telstra (Australia). Major cloud players such as AWS and Google Cloud (both United States) and Huawei Cloud and Tencent Cloud (both China) have significant facilities in the country. MNEs that have invested in data centres include NTT (Japan) with two centres, Fujitsu (Japan) with one and Zenlayer (United States) with two. Regional players such as AIMS (Malaysia) and ST Telemedia (Singapore) have also established data centres in the country.

Local data centres have partnership alliances with foreign data centre MNEs for technology and network support. For example, CS LoxInfo, a major local operator of data centres with nine facilities, is using technologies from AWS, Cisco, Dell Technologies, Hewlett Packard, Microsoft Azure and VMWare (all United States) as well as VeeAM (Switzerland). DataPro Computer Systems is working with RedHat Linux and Microsoft (both United States) to manage its data centres. True Internet Data Center has access to the cloud ecosystems of Amazon Cloud and Google Cloud (both United States), and Huawei and Tencent (both China).

Demand for data centres in *Viet Nam* is growing. The data centre market in Viet Nam was valued at over $728 million in 2019 and is projected to grow at 14.6 per cent CAGR during 2019–2025, to reach $1.6 billion by 2025. Rapid manufacturing growth, e-commerce activities, the roll-out of 5G networks and demand from cloud services are expected to push demand for data centres. Viet Nam's cloud service market was valued at $165 million in 2018 and is projected to reach $291 million by 2024.[12] The country's data security law requires data centres and data residency to be in Viet Nam, which has implications for demand for data centre facilities in the country.

There are more than 20 data centres in Viet Nam. The top five data centres operators account for 75 per cent of facilities in the country and are mainly local companies. However, in contrast, foreign MNEs play an important role in the development of cloud facilities. Viet Nam has 43 cloud service providers and the top five, all foreign MNEs, account for 30 per cent of the cloud market.[13] These five providers are PCCW (Hong Kong, China), Telstra (Australia), Cogent Communication (United States), China Telecom and Tata Communication (India), in that order. Other cloud providers include China Mobile, SingTel, StarHub and Telin (all Singapore), Verizon (United States), and Vodafone (United Kingdom).

Investors in data centres are mostly from China, Japan, Malaysia and the United States. They chose the joint-venture route to enter the data centres market. For instance, Telehouse Vietnam is a joint venture between KDDI and Mitsui and FPT Information Systems (Viet Nam). Global Data Service Joint Stock Company is a joint venture between NTT Communications (Japan) and VNPT Group (Viet Nam). Chunghwa Telecom (Taiwan Province of China) and Viettel Group (Viet Nam) established Viettel IDC to build six data centres. Time dotCom (Malaysia) partnered with CMC Telecom (Viet Nam). Viet Nam's top telecommunication companies, FPT Telecom International and Vietnam Technology and Telecommunication (VNTT), are also active in the data centre business and have partnered with foreign cloud companies. VNTT partnered with Cisco, IBM, Microsoft Azure (all United States) and NTT (Japan). FPT Telecom partnered with Cisco, Dell, Google, HP, IBM, Microsoft (all United States), and Internet Initiative (Japan). Zenlayer (United States) has four data centres in Viet Nam.

(a) Data centre and cloud investment

In the last three years, MNEs have evinced a growing interest in investing in data centres in the region (table 3.5). The growing market has attracted many global MNEs to establish and operate data centres in ASEAN. Investors continued to expand with more facilities in the same host country or entrance in different Member States. Three major groups of investors are contributing to the increasing numbers of data centres. They comprise telecommunication infrastructure MNEs, cloud solution companies, and data centre REITs (real estate investment trusts) and operators. Aside from greenfield investment in new facilities, MNEs are also entering ASEAN markets through mergers and acquisitions (M&As) and strategic alliances with local and other foreign partners.

Table 3.5. MNEs investment in data centres in ASEAN (Selected cases)

Company	Headquarters	Location	Date of investment/expansion	Investment value ($ million)
Alibaba Cloud	China	Indonesia: first facility Indonesia: second facility Indonesia: third facility	2018 2019 2021	.. .. ..
AWS	United States	Indonesia	2018–2027	964
Baidu Cloud	China	Singapore	2019–2020	30
CenturyLlink Technologies	United States	Singapore: second facility	2012	80

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Table 3.5. MNEs investment in data centres in ASEAN (Selected cases) (Concluded)

Company	Headquarters	Location	Date of investment/expansion	
Equinix	United States	Singapore: fourth facility Singapore: fifth facility	2020 2021	74 144
Facebook	United States	Singapore	2018–2022	1 000
Google	United States	Singapore: third facility	2018	350
Huawei Cloud	China	Malaysia Thailand: first facility Thailand: second facility Thailand: third facility	2015 2018 2019 2021	120 22 23 23
IBM Cloud[a]	United States	Indonesia	2016–2020	200
Iron Mountain	United States	Singapore	2017	100
LinkedIn	United States	Singapore	2016	58
Logos Logistics[b]	Australia	Indonesia	2021–2022	..
Megaport	Australia	Singapore	2014–2017	55
Microsoft	United States	Malaysia Indonesia	2021–2025 2021	1 000 ..
NTT	Japan	Thailand Indonesia: third facility Malaysia: fifth facility	2015 2019 2020–2021	32 500 ..
Space DC[c]	Singapore	Indonesia	2019–2020	..
Royal Orion	Japan	Malaysia	2019–2020	290
ST Telemedia	Singapore	Indonesia[d] Thailand[e]	2021-2023 2019–2021	.. >$224
Tencent Cloud	China	Indonesia	2021	..
Zoom Video Communications	United States	Singapore	2020	Expanding into Southeast Asia for the first time

Sources: Based on company websites, media and industry reports (data-economy.com, datacentrenews.asia, eweek.com, datacenterdynamics.com)
Note: Most of the investments are expansion projects.Some MNEs such as AWS, Google and Iron Mountain (all United States) have opened more data centres in other ASEAN Member States in 2020–2021.
[a] Partner with Indosat Ooredoo (an Indonesian subsidiary of Ooredoo (Qatar)).
[b] Partner with Pure Data Centers (United Kingdom).
[c] Partner with GIC (Singapore).
[d] Joint venture with Indonesian Triputra Group.
[e] Partner with Frasers Property (ultimate owner a Thai MNE).

(b) Mergers and acquisitions

M&As in data centres are concentrated in a few ASEAN Member States, mostly in Indonesia, Malaysia and Singapore. Bridge Data Centres (Singapore) acquired two data centres in Malaysia in 2018. Exabytes Capital (Malaysia) acquired Master Web Network (Indonesia), a data processing and hosting services company, and NTT (Japan) acquired Locus Telecommunication (Thailand), a wired telecommunication carrier. Princeton Digital Group (Singapore) acquired 70 per cent of XL Axiata's data centre business in Indonesia, which involves five data centres. Princeton Digital is planning to invest $1 billion in data centres in Asia, including ASEAN. In 2019, Brookfield Infrastructure (Canada) acquired DCI Data Centres in Singapore from Blackstone Group (United States) for $262 million. In 2020, Big Data Exchange (BDx) (Hong Kong, China) acquired a data centre in Singapore from Telstra (Australia),

I Squared Capital (Japan) acquired Telstra-Paya Lebar Data Centre in Singapore, and Equinix (United States) acquired a data centre in Singapore from Mapletree Industrial Trust for $91 million. Digital Edge based in Singapore acquired a majority stake in PT Indointernet (Indonesia) for $165 million in 2021.

(c) Strategic partnerships and alliances

Many data centre MNEs have established strategic alliances with local companies. Japanese data centre companies (e.g. NTT and KDDI) have expanded in ASEAN in partnerships with local companies (table 3.6). Equinix (United States) partnered with PT DCI (Indonesia) in 2012 to expand in that host country. Under the partnership, PT DCI will build and operate a data centre to provide customers with co-location, interconnection, support and monitoring services. PT DCI customers have access to Equinix's interconnected data centres in 38 strategic global markets. PT DCI also works with other service providers such as AT&T (United States). BT (United Kingdom) partnered with 1-NET Singapore in 2015. That partnership builds on BT's City Fibre network, which involves other data centres in the region. Tencent Cloud (China) partnered with Green Packet (Malaysia) in 2020 to establish a joint internet data centre in Malaysia for the deployment of Tencent Cloud services locally. Tencent provides cloud solutions, technical support and expertise.

Table 3.6. Japanese data centre MNEs in strategic partnerships in ASEAN

Japanese company	ASEAN company	Data centre locations in ASEAN
Hitachi	Sunway Information Systems	Malaysia
NTT Communications	PT DCI Philippine Long Distance Telephone TCC Technology VNPT Group	Indonesia Philippines Thailand Viet Nam
KDDI Corporation and Mitsui	FPT Information Systems	Viet Nam

Sources: Company websites.

Other foreign and local data centres in ASEAN also partner with foreign cloud and technology partners to access cloud facilities and support. Telkomsigma (Indonesia) partners with Oracle Cloud and Microsoft Azure (both United States) and Huawei Cloud (China). DTP (Indonesia) partners with Equinix (United States) to connect to various cloud networks and Datacomm Diangraha (Indonesia) has accessed to cloud platforms owned by major American and European MNEs (e.g. Microsoft (United States) and OnApp (United Kingdom)). In 2019, Tencent launched an AI-enabled cloud platform in Thailand with True IDC. AIMS (Malaysia) partners with AWS, Google Cloud Platform and Microsoft Azure (all United States) for access to cloud platforms. STT GDC (Singapore) has partnership arrangements with Alibaba Cloud (China), AWS, Google Cloud and Microsoft Azure (all United States) while FPT Data Center

(Viet Nam) with a few major American cloud companies. Foreign data centre companies such as Acronis (United States) and Epsilon Telecommunications (United Kingdom) in Singapore are connected to various cloud networks owned by European and American MNEs. Zenlayer (United States) with facilities in many ASEAN Member States have accessed to cloud networks of multiple MNEs such as IBM Cloud, Google Cloud (both United States) and Alibaba Cloud and Tencent Cloud (both China).

(d) Investment motivations

Key investment motivations in ASEAN include the strong regional economic, industrial and digital economy growth, which increases demand for data centres, storage and cloud services (table 3.7). Expanding market opportunities, government policy measures supporting Industry 4.0 transformation and deployment of 5G infrastructure networks are attracting more data centre and cloud investment. The need to operate close to clients (to establish a stronger connection with less delay and lower latency) and the growing pool of prospective industrial and digital customers in the region are also major determinants.

Many data centre or cloud service MNEs are expanding in ASEAN to meet growing demand, including demand from manufacturing companies. As more factories adopt automation and advanced manufacturing technologies (e.g. the IIoT, big data, sensors and AI), the demand for data storage and cloud computing facilities increases.

Table 3.7. Drivers of FDI in data centres in ASEAN

Company	Headquarters	Reasons for locating in ASEAN
Alibaba Cloud	China	Increasing demand for cloud technologies and services from rapid growth of the region's industrial and digital economy.[a]
AWS	United States	Market opportunities, economic growth and increasing demand for data centre and cloud facilities.
China Mobile International	Hong Kong, China	A region with a rapid growing demand for digital infrastructure. Some Member States' efficient infrastructure, extensive submarine cable networks and market opportunities are key reasons.
CyrusOne	United States	CyrusOne is opening a data centre facility in Singapore to serve leading oil and gas customers, and to meet growing demand.
Digital Realty	United States	Southeast Asia has emerged as a highly sought-after region, with some countries offering attractive locational factors (e.g. low-risk geographic features, abundant connectivity options and host many MNEs). Indonesia and Malaysia are rising stars in the data centre industry with Singapore as an attractive location. They offer ease of access, lower cost of entry and a fast-growing base of tech-savvy consumers to drive data storage needs, and they possess the physical capabilities to generate their own supplies of renewable energy.[b]
Epsilon Telecommunications	United Kingdom	Singapore has emerged as a hub for cloud services in the Asia-Pacific region and provides reliable infrastructure that can support growing demand for cloud. Indonesia is a fast-growing cloud market in Southeast Asia.
Equinix	United States	Market opportunities and growing demand for data centre facilities and managed services. Some ASEAN countries are key regional hubs for cloud service providers. Equinix continues to expect high demand for data centres and interconnection in Southeast Asia. Businesses, organizations and industries are increasingly digitalizing, and need to address growing data volumes and data exchange velocity.[c]

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Table 3.7. Drivers of FDI in data centres in ASEAN (Concluded)

Company	Headquarters	Reasons for locating in ASEAN
Fujitsu Group	Japan	Many companies are embracing cloud services as a platform to support accelerating digital businesses in the region. Many Japanese corporations are expanding into ASEAN. The data centre market in ASEAN has been growing rapidly in recent years. In counties such as Singapore, the existence of international network hub and broadband network facilities offer attractive location factors.
Google Cloud	United States	Market growth, opportunities and rapid digitization in ASEAN.
Huawei Cloud	China	Market opportunities. Huawei aims to provide stable, secure and scalable cloud platform services to local and Chinese companies in the region.
IBM Cloud	United States	Growing market and investment opportunities. IBM is expanding its presence in a few ASEAN markets to ensure that local businesses, MNEs and government organizations have access to its IT solutions and services.
KDDI/Telehouse	Japan	Growing demand for data centres and telecommunications infrastructure in ASEAN. The presence of many Japanese companies and other MNEs in the region provides business and investment opportunities.
Keppel DC	Singapore	Rising demand for data centre facilities. Digital applications such as big data, IoT, AI and cloud-based service solutions motivated the company to invest in Singapore and abroad. Other factors include market considerations and partnership opportunities with major local players, including in ASEAN.
Microsoft Azure	United States	Need to operate close to customers (public sector and corporate customers), and to provide access to Azure cloud facilities.
NetAPP	United States	The demand for storage solutions has grown rapidly in some ASEAN countries as more financial and public sector activities moved digital. Governments in these markets (e.g. Indonesia, Singapore and Thailand) have an emphasis on e-citizen services, and smart city solutions. Within ASEAN, Singapore is NetAPP main focus, while the company continued to expand in Indonesia, Malaysia, Thailand and the other ASEAN markets.
NTT Communications	Japan	Growing demand for data centres, particularly in Indonesia, where the market was growing by more than 20 per cent in 2019. Other factors include improving infrastructure, the talent pool and good government support for digital infrastructure development. The presence of foreign MNEs is another consideration. For instance, NTT Singapore's data centre hosts many Japanese MNEs. NTT continued to expand in ASEAN. It is building a fifth data centre in Malaysia and a third facility in Indonesia.
Oracle Cloud	United States	Growing demand for cloud-based services in some ASEAN countries such as Singapore, and the host country's efficient telecommunications infrastructure.
ST Telemedia	Singapore	ST Telemedia is expanding operation in the region and plans to continue to invest in existing markets such as in Southeast Asia.[d]
Tech Mahindra	India	Market opportunities, strong regional economic and industrial growth, demand for data centres and cloud solutions.
Tencent Cloud	China	Investment opportunities and a fast-growing cloud services market.
Zenlayer	United States	Market opportunities arising from rapid growth of industrial activities and the internet economy.

Source: ASEAN Investment Report 2020–2021 research, based on compagny websites, annual reports and media.
[a] *W. Media,* "Alibaba Cloud plans Southeast Asia expansion with new Indonesia data center and Philippines alliance", 3 July 2020.
[b] *W. Media,* "Southeast Asia to be fastest-growing region for data centres, sustainability a top priority, says Digital Realty", 29 October 2020.
[c] *Enterprise IT News,* "Equinix's expansion ambition", 26 August 2020.
[d] *Capacity Media,* "The data centre demand of tomorrow", 11 December 2020.

Regional data centre players are also expanding in ASEAN for similar reasons as MNEs, driven primarily by market factors (table 3.8). In some cases they are expanding regionally to access technology and network infrastructure, including gateways to other ASEAN markets and further afield. In 2018, the Campana Group (Singapore) built a data centre in Myanmar for a submarine cable landing station. Telkom Indonesia set up a subsidiary in Singapore, Telkom Indonesia International (Telin), to build and operate data centres and as a strategic gateway for the Telkom Group's technology. In 2015, Telin opened the $115 million Telin-3 data centre, where the TelkomGroup submarine cable systems are connected through Telin's domestic fibre network. The TelkomGroup submarine cable system infrastructure positions Telin-3 as a telecommunication hub and a gateway to Indonesia and to the rest of the world.[14]

Table 3.8. Intra-ASEAN investment motives in data centres

Company	Headquarters	Expanded to	Expansion motivation
AIMS Data Center	Malaysia	Singapore Thailand Viet Nam	Market opportunities in other ASEAN countries. Aspires to become a regional player
Bridge Data Centres (part of China Data Group)	Singapore	Malaysia	Accelerated demand for quality and scalable data centres due to digital transformation and cloud adoption across Malaysia
Campana Group	Singapore	Myanmar	Market opportunities and a submarine cable landing station and system linking Myanmar, Thailand and Malaysia with Singapore
CSF Group	Malaysia	Indonesia Viet Nam	Market potential and business opportunities
Finexus Group	Malaysia	Indonesia Thailand	Market opportunities in these countries, particularly to provide solutions and services to financial institutions
Keppel Data Centre	Singapore	Indonesia Malaysia	Increasing demand for data centres in these host countries
Princeton Digital Group	Singapore	Indonesia	Growing market in Indonesia
Space DC	Singapore	Indonesia	Market opportunities in Indonesia, the region's largest digital economy
ST Telemedia	Singapore	Thailand	Market opportunities arising from the host country's digital transformation and increasing demand for data centres
Telkom Indonesia	Indonesia	Singapore	Ability to connect Telkom Group's submarine cable systems through Telin Singapore's domestic fibre network
True IDC	Thailand	Myanmar	Increasing demand and market potential; aspires to be a prominent cloud and data centre provider in the host country

Sources: Company websites and media.

3.3.3. Data centre and cloud MNEs

ASEAN has attracted many categories of MNE data centre investors, operators and technology providers, including regional companies (table 3.9). They are involved in the development of data centre infrastructure, providing wholesale and retail (co-location) services and cloud facilities (e.g. storage, managed services, data analytics and AI). The same MNE can be involved in multiple segments of the data centre business. For instance, some operate as cloud

companies (e.g. Fujitsu (Japan) with its Enterprise Cloud, and Big Data Exchange (Hong Kong, China) with its hybrid cloud), offer co-location facilities and also establish and own data centres. Microsoft Azure (United States) offers cloud services and has data centres in Singapore, and Alibaba Cloud (China) has established data centres in Indonesia, Malaysia, and Singapore.

Table 3.9. Categories of data centre investors in ASEAN

Category	Activity	Examples of companies
Cloud companies	Mostly technology companies that operate cloud businesses, renting or building data centres for their own use or operating as cloud service providers Increasingly investing in hyperscale data centres with huge investment costs May participate in co-location activities	AWS, IBM, Google, Microsoft (all United States), Alibaba, Baidu and Tencent (all China)
Data centre realty company	Companies that invest in, build and own data centres as real estate that they rent to third parties or that they operate as co-location spaces	Ascendas REIT (Singapore), Digital Realty (United States), Keppel DC (Singapore), PT DCI (Indonesia)
End users of data centre services	Companies that use data centre facilities, some of which also build their own (i.e. enterprise data centres) to accommodate their group's growing data and computing needs	Facebook (United States) and digital media and teleconference companies (e.g. Zoom)
Fabric network providers and data centre operators	Companies that connect digital infrastructure and services on demand at software speed through secure, software-defined interconnection	Equinix (United States), Epsilon (United Kingdom), Zenlayer (United States)
Satellite/subsea cable and infrastructure operators	Companies that provide infrastructure connection and link data centres and cloud companies	Internet exchanges DeCix (Germany) and SES S.A. (Luxembourg)
Telecommunication companies	Telecommunication companies that invest, own, operate and manage data centres and offer co-location facilities	Axiata (Malaysia), China Mobile, China Telecom, NTT (Japan), SingTel (Singapore), True Communications (Thailand), Vodafone (United Kingdom)

Source: ASEAN Investment Report 2020–2021 research, based on Cloudscene, industry reports and media.

(a) Telecommunication companies

Foreign and ASEAN telecommunication operators have established data centres to gain a stronger foothold in ASEAN's fast-growing data centre market and as a natural offshoot of their core telecommunication business. These companies expanded downstream to capture more of the value chains in communication and connectivity infrastructure. Examples of these MNEs include Axiata (Malaysia), China Mobile, China Telecom, KDDI (Japan), Nokia (Finland), SingTel (Singapore), ST Telemedia (Singapore), Telkom Indonesia (through Telin), True Corporation (Thailand) and Viettel (Viet Nam).

Some telecommunication infrastructure companies such as Axiata (Malaysia) and NTT (Japan) are investing in multiple data centres in ASEAN. NTT established a $152 million data centre in Singapore in 2012 and a $32 million facility in Bangkok in 2015, and is building a $500 million data centre in Jakarta, which will be its third in that host country. It also has five data centres in

Malaysia and five facilities in the Philippines and 1 in Viet Nam. Other telecommunication MNEs such as BT (United Kingdom) and Huawei (China) also have data centres in the region. Huawei built a $120 million data centre in Malaysia in 2015 and is building a third centre in Thailand.

(b) Data centre developers or REITs

Some companies purely build and rent out their data centre real estate to local and foreign data centre operators and cloud companies. For instance, *Keppel Corporation* (Singapore) is involved with the development, ownership and management of data centres through Keppel DC and Keppel REIT. Keppel DC provides data centre facilities to clients, while Keppel REIT invests in a portfolio of income-producing real estate assets, including data centres. It has more than 20 data centres in Asia-Pacific (including 6 in Singapore, 2 in Malaysia and 1 in Indonesia) and in Europe. Keppel Corporation continues to expand in ASEAN and is building a greenfield data centre for a third-party customer in the State of Johor, Malaysia. In Indonesia, Keppel DC partnered with the Salim conglomerate group to establish the Indo-Keppel Data Center. Keppel DC also partners with other MNEs on related technology for its data centres, including Huawei (China), Cloud Engine Network Technology (China), DE-CIX (Germany), Royal Vopak (Netherlands), and Toll Group (Japan).

(c) Data centre operators

Some MNEs are major players in this category. They specialize in providing (owning and managing) and also investing in data centres. *Equinix* (United States), a major operator, provides clients with facilities, interconnection solutions and data management services. It operates five data centres in Indonesia and five in Singapore. Other data centre operators, including Colt Technologies (United Kingdom), Digital Realty (United States), Epsilon (United Kingdom), KDDI/Telehouse (Japan) and Zenlayer (United States), have also established multiple data centres in the region.

Many data centre operators provide co-location facilities to third parties. For example, foreign and ASEAN companies co-locate in Equinix data centre facilities, using its platform and cloud exchange fabric. A diverse mix of companies (foreign and local) co-locate in Equinix's Indonesia data centres. They include financial service institutions (banks, insurers and credit card payment processors), internet companies, mobile network operators providing wireless service and multinational corporations. Equinix's Singapore data centres are business hubs for more than 700 companies operating in financial services, cloud services, biomedical sciences, IT, communications, media, physical sciences and engineering industries. Examples of MNEs co-locating in those data centres include ABN Amro (Netherland), cloud infrastructure provider Digital Ocean (United States), NetActuate (United States), cloud service provider Ready Space (United States), Salesforce.com (United States) and Tata Consultancy Services (India).

Some cloud providers also use Equinix's data centre facilities and technologies. These companies include Telstra (Australia) with data centres in Malaysia, the Philippines, and Thailand; Huawei Cloud with data centres in Malaysia, Singapore and Thailand; PT Dwi Tunggal Putra (Indonesia) with five data centres in Indonesia; PT Mora Telematika (Indonesia) with six data centres in Indonesia; and Racks Central (Singapore).

(d) Global top 15 providers of data centre co-location

The 15 largest data centre co-location providers accounted for about 50 per cent of the $54 billion global data centre market in 2020. All but three have a presence in ASEAN (table 3.10). Their presence is a testament to the importance of the ASEAN markets for data centre activities. MNEs that specialize in realty data centres facilitate rapid growth in the data centre industry in ASEAN by offering co-location facilities. For example, China Telecom has four data centre operations in Singapore under a collocating arrangement involving the facilities of Equinix (United States). Cisco (United States), a major cloud provider, has data centre operations collocated in Equinix facilities in Singapore.

Given their realty and data centre infrastructure business, most of these MNEs have built multiple data centres in the region, in many cases concentrating in Singapore. The high level of geographical concentration is influenced by host countries' relatively more efficient infrastructure connectivity, more developed digital ecosystems and thriving digital economies and the existence of other digital-related facilities. GDS (a China–Singapore joint venture) has operations mostly in China but is 40 per cent owned by ST Telemedia (Singapore).

Of the top 15, companies from the United States make up the largest group (7) in ASEAN. They focus on data centre realty development and operations, and are located primarily in Singapore. Equinix has more than 10 data centres in the region. The remaining data centre investors from the United States operate only in Singapore. In contrast, three of the four largest data centre realty operators from China have facilities in multiple ASEAN Member States. They are China Mobile, China Telecom and China Unicom. A key driver for the multiple locations is the expanding presence of Chinese firms in the region such as Alibaba, ByteDance, Ctrip, Lazada and Shopee (parent company Sea is backed by China's Tencent).[15]

Table 3.10. Global top 15 data centre co-location providers, by market share, 2020 (Per cent)

Company	Nationality	Activity	Global market share (%)	Activities in ASEAN (Selected cases)
Equinix	United States	Data centres, co-location, connectivity services (cloud and internet exchange), Equinix marketplace	11.10	Indonesia: five data centres in partnership with DCI Indonesia Singapore: five data centres which include internet peering exchanges
Digital Realty Trust	United States	Data centres, co-location, connectivity, cloud, digital platform	7.60	Singapore: three data centres
China Telecom	China	Managed data services, integrated information application services, internet access services, mobile voice services, cloud, data centres	6.10	Indonesia: two PoPs, one own data centre and one in co-location facility Philippines: one data centre Malaysia: two PoPs Singapore: five PoPs, 12 data centres in co-locations, one data centre owned by China Telecom Thailand: two PoPs Viet Nam: three PoPs

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Table 3.10. Global top 15 data centre co-location providers, by market share, 2020 (Per cent) (Concluded)

Company	Nationality	Activity	Global market share (%)	Activities in ASEAN (Selected cases)
NTT GDC	Japan	Data centres, co-location and interconnection services	4.30	Indonesia: two data centres Malaysia: five data centres Philippines: five data centres Singapore: three data centres Thailand: two data centres Viet Nam: one data centre
China Unicom	China	Data centre services include cloud interconnection, cloud bond, customized data centre services	4.20	Indonesia: one data centre, one PoP Malaysia: one data centre, two PoPs Philippines: one data centre, one PoP Singapore: one Cloudbond, one data centre, five PoPs Thailand: one data centre, two PoPs Viet Nam: two data centres, two PoPs
China Mobile	China	Data centre services include cloud interconnection, cloud bond, customized data centre services	2.10	Singapore: one data centre
CyrusOne	United States	Enterprise data centres, co-location services	1.90	Singapore: one data centre
KDDI Telehouse	Japan	Data centres, co-location, connectivity, managed services, Cloud services, disaster recovery	1.90	Singapore: one data centre Viet Nam: one data centre
GDS	China	Developer and operator of data centres in China	1.60	None, but ST Telemedia (Singapore) owned 40 per cent stake
Global Switch	United Kingdom	Developer and operator of data centres	1.40	Singapore: two data centres
21Vianet	China	Data centre, co-location, interconnectivity, hybrid IT services, cloud services	1.40	None
CoreSite	United States	Data centres, co-location, cloud services, interconnection solutions	1.30	None
Cyxtera	United States	Data centres, co-location	1.20	Singapore (two data centres)
Lumen	United States	Edge computing, hybrid IT and cloud, managed and IT services, networking	1.10	Singapore (one data centre)
Flexential	United States	Co-location, connectivity, cloud, managed services, disaster recovery	1.10	None

Sources: Based on ranking by Structure Research, "Global Colocation and Interconnection Market: 2020 Update. ", company websites, industry reports and media.
Notes: ICT = information and communication technology, IT = information technology, PoP = point-of-presence.

(e) Cloud companies

Cloud MNEs such as AWS and Zenlayer (box 3.2) and other major companies are in ASEAN (e.g. Alibaba Cloud, IBM Cloud, Google Cloud, Huawei Cloud, Microsoft Azure, Oracle Cloud and Tencent Cloud). These cloud MNEs operate in several ASEAN countries. Google Cloud has data centre facilities in Indonesia and Singapore; Alibaba Cloud in Indonesia, Malaysia and Singapore; Tencent Cloud in Malaysia (under construction), Singapore and Thailand (under construction).

In 2018, Google (United States) established a third data centre in Singapore, increasing its total investment in data centres in that host country to $850 million. The company built its first Southeast Asia data centre in Singapore in 2011 and its second in 2015. Facebook (United States) is committing huge investment in data centres in ASEAN. IBM Cloud (United States) has operations in Indonesia and Singapore. Chinese companies are also actively expanding in ASEAN. Alibaba has cloud operations in multiple ASEAN countries. Baidu Cloud (China) is establishing a data centre in Singapore. Royal Orion (a Japanese subsidiary in Malaysia) is constructing a $290 million green data centre in Malaysia.

Box 3.2. Cloud companies with data centres in ASEAN

Cloud MNEs play an important role in linking enterprises and manufacturers with digital infrastructure (e.g. data centres). They do so by providing clients with co-location facilities, computing, data processing, database access and data analytic needs, including helping them to connect through their global networks and platforms. More cloud MNEs are investing in ASEAN and in multiple locations.

Zenlayer (United States) is an edge cloud service provider. It has 19 edge data centres in ASEAN, providing edge computing, managed hosting and co-location solutions. The company expanded in the region because of the large regional market, increasing demand for its online and cloud services, and the region's rapidly growing digital economy. It has one data centre in Cambodia, two in Indonesia, two in Malaysia, one in Myanmar, three in the Philippines, five in Singapore, two in Thailand and three in Viet Nam.

It also has partnership arrangements with ASEAN-owned data centres to serve clients in the region. For instance, it partners with PLDT, a local provider of information and communication technology (ICT) and digital services in the Philippines, to offer wide area network technology that connects enterprise networks, data centres and clouds services to clients. In Singapore, it partnered with Telin (a subsidiary of PT Telkom Indonesia) in 2019 to bring cloud networking to clients in Southeast Asia, connecting them with other data centre and cloud facilities in different parts of the world. The partnership covers Telin's Singapore data centres and some of Telkom Indonesia's data centres in Indonesia. In the same year, Zenlayer opened an international office in Singapore to serve clients in the Asia-Pacific region. The investment represents a key part of the company's strategy to strengthen relationships with local carriers, customers and other data centre providers such as Telin Singapore and SEA (a technology, gaming and e-commerce company).

AWS (United States) provides cloud infrastructure service, platform as a service and packaged software as a service through its data centres in different parts of the world. It also offers services such as computing power and content delivery. It has nine data centres in ASEAN and is establishing a cloud region in Indonesia. It has edge data centres in Malaysia (two), the Philippines (one) and Singapore (four; and a cloud region). AWS clients in ASEAN include start-ups, SMEs, local firms and MNEs operating in manufacturing and services industries, as well as government institutions. Its cloud services cover data storage, scalable platforms, the IoT, data analytics and machine learning tools (box table 3.2.1).

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Box 3.2. Cloud companies with data centres in ASEAN (Concluded)

Box table 3.2.1. AWS: Cloud services to clients based in ASEAN

Client	Host country	Activity	Type of cloud solutions
Carro	Singapore	An automotive marketplace and car financing start-up	Provides computing services, storage, database and network connectivity, using AWS relational database service to store thousands of pictures and over 3TB of information across multiple geographies.
Concepcion Industrial Corporation	Philippines	A maker of electrical appliances	Provides cloud computing services, data storage, security and networks.
DoHome	Thailand	A retail and wholesale store	Provides cloud facilities, security, support for scalability, and 24/7 server runtime.
Globe Telecom	Philippines	A provider of domestic telecommunication services	Provides various cloud services to support daily business internet workloads and processes.
Optik Seis	Indonesia	An optical company	Provides cloud solutions for web and mobile applications, to enable automatic scaling service during spikes in data traffic.
Petronas Lubricants International	Malaysia	A lubricants manufacturing arm of Petronas	Provides cloud facilities to handle standardized application processes and consolidated multiple application systems, enabling advanced services such as serverless, IoT and data lakes to serve business users and customers.
Seaco	Singapore	A Chinese sea-container leasing company	Provides cloud solutions storage capacity, networking, administration and security to address computing infrastructure needs.
Toyota Tsusho Electronics	Thailand	An automotive subsidiary of Toyota (Japan)	Provides huge, scalable computing processing facilities for real-time traffic data traffic from over 50 000 vehicles, using a traffic information broadcasting system.
Zimplistic	Singapore	A start-up manufacturer of a smart, automated, flatbread-making machine	Provides cloud applications and solutions, and serverless computing service to run code in response to events and process incoming data from internet-connected machines, database service and analytics, helping process more than 84 million data packets a day from machines worldwide.

Sources: AWS and company websites.

Sources: Company websites, industry reports and media.

(f) Global top 15 cloud MNEs

The top 15 cloud services MNEs are a mix of providers, from those that offer data storage, databases, cybersecurity and cloud computing functions (e.g. AWS, Hewlett Packard, Microsoft Azure and Cisco (all United States)) to those that offer specialized cloud software for sales (e.g. Salesforce) and enterprise resource management (e.g. Workday (United States)). All of the top 15 except DropBox operate in ASEAN (table 3.11). Most are data centre owners and specialized co-location companies. In contrast to realty data centre MNEs, these cloud providers operate diverse facilities (e.g. data centres, points of presence, distribution nodes and edge locations) with multiple data centres in several ASEAN Member States.

A key feature of these cloud operators is the relatively large number and size of their data centres in the region. In some cases, the scale of their investments in data centres is huge as they build hyperscale and new-generation data centres. Some build enterprise data centres, mainly to serve their needs and in some cases also offer co-location facilities to third companies. Despite their already significant investment, these cloud operators have continued to expand in ASEAN with new data centres.

The investment cost of a data centre, depending on size and features, can reach more than $1 billion. For instance, the Facebook (United States) data centre in Singapore cost about $1 billion. Google, AWS, Microsoft (all United States) and Telekom Malaysia are building hyperscale data centres and cloud services in Malaysia at an estimated investment cost of $3–3.7 billion over the next five years. In Indonesia, AWS is building a $ 2.8 billion data centre, and Alibaba (China) is opening a third data centre in 2021 and will invest heavily in the project over the next three years.[16] These four cloud MNEs (Google, Microsoft, AWS and Alibaba) together are investing significantly in data centre and cloud facilities in ASEAN.

Table 3.11. Top 15 global cloud computing companies

Company	Nationality	Activity	Global cloud revenue ($ billion)	Presence and activities in ASEAN (Selected cases)
Microsoft Azure	United States	Cloud computing services and platform	52	Singapore (one region with two data centres)
Amazon Web Services	United States	Broad range of applications including storage, databases, networking, analytics, machine learning and AI, IoT, security, and application development	35	Indonesia (one region) Indonesia, Malaysia, Philippines, Thailand, Viet Nam (offices) Malaysia (two edge network locations) Philippines (one edge network location) Singapore (one region, four edge network locations)
Hewlett Packard Enterprise	United States	Cloud services, IT infrastructure	13	Singapore (Global IoT Innovation Lab, edge centre)
Salesforce	United States	Customer relations management cloud platform, AI, analytics, security, systems automation	13	Singapore (one office, two data centres)
Cisco Systems	United States	Data centre, cloud applications, IoT, managed services, integrated solutions, networking, security, analytics	12	Singapore (one data centre (in co-location at Equinix) and one co-innovation centre)
Dell Technologies/ VMWare	United States	Cloud services, converged infrastructure, data protection, data storage, hyperconverged infrastructure, networking	11	Singapore (Global Innovation Hub, includes augmented/mixed reality, data analytics, cloud-native, cybersecurity, edge computing)
IBM Cloud	United States	Cloud solutions, connectivity, data centre, managed services, disaster recovery, AI, IoT	9	Indonesia (VPS (virtual private server)) Malaysia (VPS) Singapore (one data centre and one network point-of-presence)

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Table 3.11. Top 15 global cloud computing companies (Concluded)

Company	Nationality	Activity	Global cloud revenue ($ billion)	Presence and activities in ASEAN (Selected cases)
Google Cloud	United States	Internet-related services and products, search engine, cloud computing, and software	9	Indonesia (one cloud region, which includes three cloud zones involving four edge locations and one data centre) Singapore (one region, which includes three zones (includes three data centres, three edge locations))
Adobe	United States	Creative cloud, marketing, analytics, data platforms	7	Singapore (one data centre that is in co-location at digital realty)
SAP	Germany	Enterprise application software, machine learning, IoT, and advanced analytics technologies	7	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam (offices) Malaysia (1 data centre) Singapore (1 data centre)
Oracle Cloud	United States	Storage, database, networking services, security, integration, analytics, and developer services	5	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam (offices) Malaysia (digital and cloud solution hub) Singapore (digital and cloud solution hub, one data centre)
Alibaba Cloud	China	Cloud computing, web hosting, security, database, application stacks, operating system, big data)	4	Indonesia (one region with two zones involving two data centres; distribution of network nodes) Malaysia (one region with two zones involving two data centres; distribution of network nodes) Philippines (distribution of network nodes) Singapore (one region with three zones involving three data centres; distribution of network nodes) Thailand (distribution of network nodes) Viet Nam (distribution of network nodes)
Workday	United States	Finance, human resources, and planning system on cloud (enterprise resource management)	4	Indonesia, Malaysia and Singapore (offices)
ServiceNow	United States	Workflow platforms that incorporate machine learning, an intelligent chatbot, performance analytics, AI-powered search, process optimization technologies	3	Singapore (one office and one data centre)
DropBox	United States	File hosting service provider	2	None

Source: Based on "15 biggest cloud computing companies in the world", Insider Monkey.

Chinese technology and telecommunication MNEs are expanding rapidly in ASEAN to provide services to a growing number of Chinese and other companies, including gaming and e-commerce enterprises (table 3.12). Some Chinese data centres and cloud providers support their group's digital ecosystem, e-commerce and payment platforms in ASEAN (e.g. Alibaba and Tencent).

Table 3.12. ASEAN: Data centres and cloud services of Chinese MNEs

Company	Selected operations in ASEAN
CITIC Group (through Acclivis)	Indonesia, Malaysia, Singapore, Thailand
Huawei Cloud	Malaysia, Singapore, Thailand
Baidu	Singapore
Tencent Cloud	Malaysia, Singapore, Thailand
Alibaba Cloud	Data centres: Indonesia, Malaysia, Singapore Distribution network nodes: Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam Cloud region: Malaysia, Singapore

Sources: Company websites, industry reports and media.

Alibaba Cloud provides data centre facilities and cloud computing services to two major groups of customers in ASEAN:

(i) Companies in its group. Alibaba's data centres and cloud services strengthen the group's digital ecosystem in ASEAN to support its various digital businesses such as e-commerce, payment systems and logistics operation. Alibaba Cloud provides infrastructure support, digital solutions, storage and data centre facilities to the Alibaba group in ASEAN.

(ii) Local and other foreign companies. For instance, in Indonesia, Alibaba's clients include PT IndoInternet, PT Sistech Kharisma and PT Blue Power Technology. In Malaysia, they include Muamalat Bank, Sena Traffic Systems, AirAsia, Atilze, Revenue Monster, TNG Digital and Ground Team Red. In Singapore, some of its third-party customers include Innovative Hub, Bamboo System Technology and SingPost.

Another example is Tencent Cloud. One of its major customers in Southeast Asia is Shopee, a major e-commerce platform with operations across multiple ASEAN countries. Shopee used Tencent Cloud's nodes in Hong Kong (China) and Singapore as resource pools to meet fluctuating demands in major sales promotions. Tencent also launched in Southeast Asia a cloud gaming platform called ChinaJoy, which competes for market share with Xbox and Playstation.[17]

Other Chinese MNEs (e.g. Huawei Cloud and Baidu Cloud) are expanding in the region with more data centres, partly influenced by their group's growing business operation and the growing number of Chinese companies demanding cloud services. Huawei has cloud and data centre-related projects in ASEAN, which involve building a cybersecurity lab in Malaysia as well as conducting joint research and innovation projects with the Thailand National Science and Technology Development Agency and the National Innovation Agency. Huawei is providing 5G technologies to some ASEAN-owned telecommunication companies that also demand cloud facilities.

(g) Other major data centre operators in ASEAN

Other major data centre operators also have a significant presence in ASEAN. They consist of end users of data centre services and a mix of data centre operators (e.g. co-location and

cloud service providers). Some end users of data centre services or "enterprise data centre" owners (table 3.13), such as social media company Facebook, digital media company Oath (Verizon), and video communications platform Zoom (all United States) have established or are establishing data centres in the region to support their operations. Their investments in data centres are concentrated in one or two ASEAN Member States.

Some of these data centre operators are geographically diversified, with investment covering more ASEAN countries such as Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Zenlayer has more than 20 data centres in eight ASEAN countries. Tech Mahindra (India) has data centres in Indonesia, Malaysia and Singapore that complement its IT consulting services and support its BPO operations in the region (it has a large operation in the Philippines).[18] Continent 8 Technologies (United Kingdom) is in the Philippines and Singapore, and Epsilon Telecommunications (United States) in Indonesia, Malaysia and Singapore. Fujitsu (Japan) offers both cloud and co-location services to clients in ASEAN with four data centres in Singapore and Thailand.

Table 3.13. Other MNEs in the data centre market in ASEAN, 2020

Company	Type of data centre player[a]	Nationality	Activity	Presence in ASEAN (Selected cases)
Baidu	Cloud provider	China	Cloud services, data centre, AI, connectivity	Singapore: one data centre
Big Data Exchange	Data centre provider	Hong Kong, China	Hybrid cloud, connectivity and co-location	Singapore: one data centre
Bigo Technology	Enterprise data centre owner	Hong Kong, China	Social media app	Singapore: one data centre
BSO	Data centre provider	United Kingdom	Network, cloud, hosting and managed services	Malaysia: one data centre Singapore: three data centres
Colt Technology Services	Data centre provider	United Kingdom	Data centre, co-location, connectivity services	Singapore: one data centre
Consoleconnect by PCCW Global	Software to enable data centre interconnectivity	Hong Kong, China	Aoftware to enable connectivity in data centres	Indonesia: two data centres Malaysia: two data centres Philippines: two data centres Singapore: 16 data centres Thailand: two data centres Viet Nam: two data centres
Continent 8 Technologies	Data centre provider	United Kingdom	Connectivity, cloud, data centre, co-location, managed services, security and disaster recovery	Philippines: one data centre, one PoP Singapore: one data centre, one PoP
CyrusOne	Data centre provider	United States	Real estate investment trust that invests in carrier-neutral data centres and provides co-location, peering services, cloud and connectivity solutions	Singapore: one data centre

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Table 3.13. Other MNEs in the data centre market in ASEAN, 2020 (Concluded)

Company	Type of data centre player[a]	Nationality	Activity	Presence in ASEAN (Selected cases)
Epsilon Telecommunications	Data centre provider	United Kingdom	Data centre, co-location, cloud, remote peering, voice, multi-service port	Indonesia: one PoP Malaysia: one PoP Singapore: one data centre
Facebook	Enterprise data centre owner	United States	Social media company	Singapore: one data centre
Fujitsu Cloud	Data centre provider	Japan	Data centre, dedicated hosting, co-location services, managed services, web hosting, broadband internet services, disaster recovery services, operations support	Singapore: three data centres Thailand: one data centre
Huawei Cloud	Cloud provider	China	Enterprise networking, cloud data centre, enterprise IoT, intelligence video surveillance	Malaysia: four data centres Singapore: two data centres Thailand: two data centres
Katalyst Data Management	Enterprise data centre owner	Canada	Cloud services, data recovery, complete data management solution for oil and gas companies	Malaysia: one data centre
NetActuate	Data centre provider	United States	Peered networks	Singapore: two data centres
Nokia	Data centre services	Finland	Multivendor data centre services	Singapore
Regal Orion Data Center	Data centre provider	Japan	Managed services, cloud services, co-location, network services	Malaysia: one data centre
Telia Carrier	Data centre services and fibre backbone	Sweden	Fibre backbones, provides business-critical networking services to data centre operators, content providers and enterprises	Singapore
Tech Mahindra	Data centre provider	India	IT-based services including data centre, cloud services, managed services	Indonesia: one data centre Malaysia: one data centre Singapore: one data centre Thailand and Viet Nam: offices
Telstra Global	Data centre provider	Australia	Data services, data centres, co-location, cloud services	Malaysia: one data centre Philippines: one data centre Singapore: five data centres
Tencent Cloud	Cloud provider	China	Cloud computing, security, networking, big data, AI, developer tools	Singapore: one region/data centre, Thailand: one region/ data centre
Zenlayer	Data centre provider	United States	Bare metal cloud, cloud networking, co-location, managed hosting	Indonesia: two data centres Malaysia: two data centres Philippines: three data centres Singapore: five data centres Thailand: two data centres Viet Nam: three data centres
Zoom	Enterprise data centre owner	United States	Video communication	Singapore: one data centre

Source: *ASEAN Investment Report 2020–2021* research, based on company websites, annual reports and media.
Note: PoP = point-of-presence
[a] Classification is based on description given by company.

(h) Regional players

ASEAN companies are also active investors and emerging players in data centre and cloud solutions in the region. Their operations have also added to the rising intra-ASEAN investment. They include AIMS, CSF Group Data Center, Telekom Malaysia and Finexus (all Malaysia); CBN and Telkom Indonesia (both Indonesia); Keppel Data Centres, Singtel DC, Space DC, ST Telemedia and ViewQWest (all Singapore); and True IDC (Thailand). Singtel (Singapore) has a partner network of more than 50 data centres to establish a footprint in Asia-Pacific, including in Malaysia and Thailand. ST Telemedia (Singapore) has data centre facilities in a few ASEAN countries and CSF Group (Malaysia) has established data centres in Indonesia and Viet Nam.

3.4. INDUSTRIAL AUTOMATION AND ROBOTS

The market for equipment and solutions for IA and process control in ASEAN is expected to grow at about 8 per cent per year from 2019 and reach $5 billion by 2025.[19] The rate of industrial robot adoption in some ASEAN Member States (e.g. Singapore, Thailand and Viet Nam) is rising. A few factors drive this trend.

First, IA MNEs are expanding investment in manufacturing hardware and supplying automation solutions to a growing pool of manufacturers. Second, more manufacturing firms (foreign and local companies) are adopting or upgrading production systems with advanced industrial and digital technologies. Third, governments in ASEAN are actively encouraging firms to adopt technologies to strengthen the competitiveness of manufacturing industries and for Industry 4.0 transformation (see chapter 4). In most cases, they provide incentives, including institutional support for firms to automate or digitalize.

IA is not new to the manufacturing industry in ASEAN (box 3.3). Adoption of IA in the region started in the 1970s with MNEs in Malaysia and Singapore that continuously upgrade their factories. The automotive and electronics industries, led by MNEs, were the two front runners in using IA (ILO, 2016 and Business Sweden, 2019).

Some manufacturing industries (e.g. automotive and electronics) have a higher degree of IA and robot application because of their high-volume operation orientation. MNEs and local companies in these industries upgraded their factories with advanced IA system, which involved a combination of connected digital technologies to achieve smart manufacturing. This would include machine learning, big data analytics, preventive maintenance, real-time problem solving and remote control of plant operations (section 3.6).

Box 3.3. Early IA by electronics MNEs in Malaysia and Singapore

Malaysia and Singapore have been major locations for electronics manufacturing since the early 1970s, when many global MNEs established a presence in these two countries. These MNEs include AMD, Intel, Motorola, National Semiconductor (all United States), Hitachi (Japan), and Litronix and Siemens (both Germany) (*AIR 2017*). Whereas low-cost labour was a key driver for the location choice in those days, since then many MNEs have gradually introduced automation and robots to their factories, from mechanization and process control technology to advanced IA.

The adoption of automation has been prominent among major electronics MNEs, especially those involved in producing semiconductors. The examples of United States MNEs (Motorola and Intel in Malaysia, and Micron Technology and 3M in Singapore) demonstrate the early IA in electronics production that took place in these two ASEAN Member States.

Motorola (United States) established a supply chain operation (producing telecommunication components and equipment, including semiconductors) in Penang, Malaysia in 1974. The shift from manual to mechanized and subsequently to automated processes took place in several stages:

- Before 1980: manual production and inspection
- 1980–1985: mechanization of individual steps (such as pick and place) using pneumatic controls and, later, microprocessors
- 1985–1990: extensive use of robots for individual steps and small assembly sequences
- 1990–1993: vision systems and computer-aided drawing and manufacturing initiated.

Between 1987 and 1993, Motorola invested about $75 million in advanced manufacturing technologies in its Penang operations. By 2000, they were fully automated. The company has continued to expand and upgrade its operations with more advanced IA to achieve efficiency. In 2014, it opened a research and development centre in Penang, its largest R&D centre outside of North America. The centre is equipped with state-of-the-art laboratories, and product design and development capabilities. In 2016, it launched the Network Operations Centre in Penang to monitor and manage customers' essential communications using advance technologies, embedded sensors, IoT and analytics. Some of the advanced solutions developed by Motorola Penang R&D facility are smart belts, body-worn cameras, LTE devices, and sensors that provide location and biometric readings.

Intel (United States) established an assembly and manufacturing presence in Penang in 1972 to take advantage of the abundant pool of low-cost and trainable workers. Automation at Intel Penang started in 1978. Technology upgrading encouraged the gradual transfer of its United States testing operation to the Penang facility. Intel Penang's production is automated (i.e. process automation and adoption of smart technologies) with an advanced automation system and statistical process controls that support high-volume manufacturing.

Micron Technology (United States) has invested more than $15 billion in Singapore since 1998. Its operation then was mainly manual. It has transformed into a fully automated operation as it has continued to develop higher-technology semiconductors. Today, Micron Singapore has adopted advanced IA and robots, and developed a smart factory. It has also provided technology solutions and equipment to support clients in digitalizing their manufacturing processes. In 2018, it completed the expansion of a centre of excellence (a NAND flash memory fabrication facility) in Singapore with the application of AI, data analytics and IIoT technologies and autonomous transportation.

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Box 3.3. Early IA by electronics MNEs in Malaysia and Singapore (Concluded)

The centre is equipped with smart manufacturing technologies. Micron partnered with NXP Semiconductors (Netherlands– United States) in the design and development of the platforms.

3M (United States) opened a sales office in Singapore in 1966. Over the decades it expanded operations with a regional headquarters, an R&D hub and two cutting-edge manufacturing facilities in Woodlands (1998) and Tuas (2009). In 2016 the Tuas facility was expanded with advanced manufacturing technologies to support the production of electronics, automotive and health care products.

In addition to electronic MNEs, other industrial MNEs have also been in the region for many decades and have upgraded their factories with advanced manufacturing technologies. *Bosch* (Germany) has been present in Southeast Asia since 1922. Its operation in ASEAN includes activities from all three of its business sectors: automotive technology, industrial technology, and consumer goods and building technology. Bosch has seven automated manufacturing plants in Southeast Asia, the newest being an automotive parts plant in Viet Nam. The company adopted a smart manufacturing system in Thailand since 2017. The $96 million smart factory included the deployment of sensors in fully automated and connected manufacturing machines for data analytics. It also upgraded its plant in Viet Nam to expand production capacity and to convert the facility into a smart, connected and automated factory.[a] Since 2010, Bosch's software and engineering R&D centre in Viet Nam offers smart solutions such as embedded software, hardware, IT tools and mechanical design, and IT-enabled services. In 2019, the company upgraded the centre into one of its key IoT solution hubs in the Southeast Asian region.[b]

Sources: Company websites, industry reports (Eetimes, data centre news, iaasiaonline.com), media (the Star, Channel News Asia) and IE (Singapore).
Note: LTE = Long term evolution (a standard for wireless data transmission).
[a] *Vietnam Investment Review, "Bosch continues to expand Bosch Powertrain Solutions plant in Dong Nai'*, 17 March 2018 and *Autotech, "Bosch opens first Smart Factory for Mobility Solutions in Thailand"*, 12 December 2017.
[b] *Vietnam Investment Review, "Bosch develops innovative solutions for Industry 4.0"*, 13 February 2019.

The extent of IA adoption in the region differs significantly among Member States, corresponding with their level of industrialization and GVC participation. In more industrialized Member States (e.g. Malaysia, Singapore, Thailand) and Viet Nam, foreign and local firms have been relatively more active in adopting IA than in emerging manufacturing locations (e.g. Cambodia, the Lao People's Democratic Republic and Myanmar). Industries that are high volume oriented and firms that operate in environments with limited labour supply or high cost are more inclined to automate. In general, IA adoption is more prevalent among MNEs than locally owned factories (box 3.4).

Box 3.4. MNEs are active users of IA technology and robots in ASEAN

The degree of IA adoption also depends on the size and nationality of firms. Foreign subsidiaries are more receptive to investing in or adopting IA than local firms because of their stronger financial capacity and greater exposure to IA technologies, and the influence of their parent company's drive to automate. Subsidiaries of many MNEs such as BMW (Germany); Motorola (United States); and Toyota, Mitsubishi, Honda, Suzuki, Tanaka Precision, Sharp and Sumitomo Electric (all Japan) have adopted or upgraded IA in their factories in ASEAN.

Amgen (United States), a biotechnology company, invested more than $150 million in Singapore in a biomanufacturing facility that uses IA technologies. Robots are also used for materials handling, cleaning and environmental monitoring inside the facility's isolator for aseptic processing.

Astra Otoparts, a member of PT Astra Group (Hong Kong, China) with extensive operations in Indonesia, is a supplier to the automotive production of Toyota (Japan) in Indonesia. It started factory automation in the 2000s with support from IA MNEs such as Festo (Germany), Schneider Electric (France), and Epson, Mitsubishi Electric and Tsubaki (all Japan). In 2014, it engaged DEL (Czechia) for the conception, design, production, delivery and commissioning of a robotic automation forging line in its factory.

BMW (Germany), an automotive manufacturer, opened a plant in Thailand in 2019 to produce high-voltage batteries. The plant assembles battery modules using highly automated processes and cutting-edge production technologies such as laser welding, plasma activation, robotics, automated optical and electrical inline quality inspection, and end-of-line testing.

Dyson (United Kingdom), a designer and manufacturer of household appliances, has fully automated its manufacturing facilities in Singapore (built in 2013) and in the Philippines (built in 2018). These facilities produce motors, which require precise and accurate manufacturing processes. Twin production lines were installed in both locations with the motor-assembly almost exclusively automated, using robots for precision production. On the production line 36 workstations are monitored by a control tower in a complex manufacturing enterprise system that can slow down or speed up individual parts of the line in real time to prevent bottlenecks.

Flex (formerly Flextronics) (United States–Singapore), an electronics contract manufacturer, has automated production facilities in Indonesia, Malaysia and Singapore. In 2019, Flex partnered with Arch Systems (United States), a provider of machine-data-sensing platforms, to supply real-time access to and analysis of manufacturing data at the production facilities. Flex deploys Arch's technology to capture relevant data for analytics and to help drive production efficiency, process automation and predictive analytics.

GlaxoSmithKline (United Kingdom), a pharmaceutical multinational, established its first manufacturing plant in Singapore in 1972, a second facility in 1982 and a third in 2009. It continues to invest in technical capability, process improvement and new technology such as digital and data analytics. In 2015, it selected Siemens (Germany) to provide technology and further upgrade its manufacturing facilities, including process and equipment control. In 2019, it opened two state-of-the-art plants that use advanced manufacturing technologies, such as continuous and digital manufacturing.

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Box 3.4. MNEs are active users of IA technology and robots in ASEAN (Concluded)

National Instruments (United States), a producer of automated test equipment and virtual instrumentation software, has invested $40 million to expand and upgrade its manufacturing facilities in Penang, Malaysia. The expansion, which started in 2019, involves investments in 5G manufacturing and R&D.[a]

Procter and Gamble (P&G, United States) has many manufacturing facilities in the region that are automated with digitalized technologies.[b] P&G partnered with GE Digital (United States) in transforming its manufacturing operation by using real-time data, increasing safety and product quality. In 2018, it rolled out a purpose-built platform designed by GE to consolidate and capture manufacturing data across multiple plants in ASEAN for cloud storage and analysis. The cloud technology accelerates process implementation by up to 50 per cent and gives users a better understanding of information captured at individual sites to perform data analytics. In 2019, P&G adopted a smart control system in its factories with touchless and automated machines and seamless digitized information across the supply chain.

Tetra Pak (Sweden–Switzerland), a food processing and packaging solutions MNE, opened an aseptic-carton packaging material factory in Viet Nam in 2019. The facility uses advanced manufacturing technologies such as IIoT, connected automation and robots. In 2018, Tetra Pak announced that it was embracing Industry 4.0 technologies with a greater level of automation and simulation across its global factories. Its Viet Nam factory complements its production facilities in Singapore, which also use advanced manufacturing technologies.

Source: ASEAN Investment Report 2020–2021 research, based on company websites and media.
[a] *Digital News Asia,* "NI announces $40 million expansion of multifunctional facility in Penang", 22 November 2019.
[b] *Automation World,* "P&G puts manufacturing data in the cloud", 8 August 2019.

MNEs in ASEAN adopt automation and robotic technologies for various reasons (table 3.14). Key drivers include the need to improve production efficiency, reduce costs, replace repetitive and high-volume tasks with precision operations, and exercise better control of manufacturing process through digitalization and data analytics. Prospects for market growth and business opportunities in a vibrant manufacturing hub are additional factors. The increasing demand for IA hardware and advanced manufacturing solutions has also motivated a growing number of IA MNEs to invest in the region. Operating close to clients is important to build business relationship and facilitate sales, including to showcase automation solutions. Strong business linkages between MNEs and SME suppliers have an important influence on SMEs' adoption of automation under MNEs' vendor programmes for consistent product quality and predictability of both supply chains and production output (box 3.5).

Table 3.14. Motivations of MNEs investing in automation and robotics in ASEAN

IA technology provider	Nationality	Key drivers (or motivations)
ABB	Switzerland	Driven by rapid expansion of the region's manufacturing industry and increasing demand for IA technologies. ABB is expanding its export base for IA and robotic activities in ASEAN. In July 2019, it opened a regional robotics digital operation centre in Malaysia to harness Industry 4.0 technologies (e.g. big data analytics and end-to-end connectivity) to provide real-time monitoring and technical support for ABB robots adopted in ASEAN.
Bosch	Germany	Opened two smart factories for mobility solutions in Thailand in response to rising demand from the automotive industry. Its third mobility solutions plant, in Rayong, opened in December 2020 was encouraged by growing demand from local and global original vehicle equipment manufacturers (OEM) in the country.
Eaton Corporation	Ireland	Invested in Singapore because of the country's market attraction, its business-friendly environment and its position as a strategic business hub that drives innovation, investment and opportunities in the country and in ASEAN.
Emerson	United States	Established an automation solutions centre, a pervasive sensing centre of excellence, an analytical manufacturing and integration centre, and an additive manufacturing centre in Singapore. These centres showcase the company's IIoT automation platform and help customers adopt advanced manufacturing technologies.
Honeywell	United States	Expanded operations in ASEAN because of regional market growth potential, growing use of e-commerce and government policies that favour Industry 4.0 transformation. It opened a new regional headquarters in Malaysia as part of its strategy to tap into the growing markets in the region.
Mitsubishi Electric	Japan	Operates in many ASEAN countries. Regional integration, rapid industrial growth and market opportunities are key motivations for investments in ASEAN. In Thailand, a major automotive production hub, the company focuses on the automotive industry.
Omron	Japan	Opened two new facilities at its Cikarang (Indonesia) plant in 2016 to meet increasing demand for advanced electronic components. The $11 million facilities house an IA plant, a showroom and an automation centre.
Rockwell Automation	United States	Southeast Asia is seen as a key area for strategic growth and the company plans to increase operation in the region.
Schneider Electric	France	Attracted by ASEAN's regional integration and the growing regional market with promising opportunities. New generation of firms capable of adopting digital technologies in the region are increasing.
Siemens Industrial Automation	Germany	Rapidly growing manufacturing industry, large pool of manufacturers and proximity to clients in the region are key drivers. Market opportunities arise from the growing number of companies that recognize the need for digital transformation, and the COVID-19 disruption to supply chains has increased the drive to digitalize.
TMEIC[a]	Japan	ASEAN is an important and rapidly growing market. Its operation in Singapore coordinates its businesses across the region (e.g. Indonesia, Malaysia and Thailand). Sees future growth in markets such as the Philippines and Viet Nam.

Sources: Company websites, industry reports and media.

[a] TMEIC is a joint venture between Toshiba and Mitsubishi Electric headquartered in Tokyo specializing in industrial electric and automation systems for industrial plants. The company develops and produces power electronics apparatus, electric motors, drives and power supplies.

Box 3.5. Influence of MNEs on suppliers' adoption of digital technologies

The close business relationship between major MNEs and local suppliers have an important impact on the latter in adopting industrial automation technologies to maintain product quality and production predictability. For instance, Motorola in Malaysia works with local SMEs that are its suppliers. It takes part in joint product development with them, including influencing on lean manufacturing transformation and industrial automation at suppliers' facilities. Many of the SME-suppliers upgraded production facilities with adoption of advanced manufacturing technologies to maintain Motorola's product standards and in meeting increasing order volumes. These local SMEs include Qdos Flexicircuits Sdn Bhd, Suiwah Corp Bhd, NationGate Technology Sdn Bhd and Dufu Technology Corp Bhd.

Qdos has been upgrading its automated optical inspection and laser drill facilities at its Bayan Lepas plant. Since 2005, it has upgraded manufacturing facilities to meet the stringent product requirements demanded by the telecommunication and data storage industry. Automation transformation has helped Qdos increase monthly output by more than 15 per cent. Its plants are now equipped with highly automated state-of-the-art facilities to support a comprehensive flexible printed circuit manufacturing solution, prototype fabrication, mass-production and surface mount technology assembly.

NationGate has been upgrading production facilities since 2008. It has three plants in Prai Industrial Estate in Penang. Motorola accounts about 40 per cent of NationGate's business. NationGate's assembly and processing lines are now fully automated and integrated to achieve consistent quality and predictable rate of output. The company's production system uses data analytics to increase production efficiency.

Dufu manufactures casings and brackets for Motorola's telecommunication infrastructure. In 2009, it invested an additional 10 per cent of capital expenditure to expand and upgrade the business segment serving Motorola. The factory transformation involved adoption of advanced manufacturing technologies and automation that has enabled Dufu to achieve a "flexible manufacturing" environment that led to cost saving and increased production efficiency.

PT. Toyota Motor Manufacturing Indonesia has more than 130 companies in its supply chain. Some of its suppliers have automated and are moving towards Industry 4.0 transformation with adoption of advanced integrated industrial automation and digital connectivity. These suppliers include PT. Astra Otoparts (Hong Kong, China), PT Asmo, and Denso (Japan).

Sources: Company websites, and media reports.

3.4.1. Growing market for industrial automation

The adoption of industrial robots in ASEAN is rising, with Singapore leading, followed by Malaysia and Thailand (table 3.15). Industrial robot density in ASEAN, except for in Singapore, was below the global average for Asia (113 units per 10,000 workers in 2020 and 119 units per 10,000 workers) in 2019. Most deployment of industrial robots takes place in the automotive, electronics, and metal and machinery industries.

Singapore is one of the most automated countries in the world, with 918 industrial robots per 10,000 workers in 2019, compared with the Republic of Korea (868), Japan (364), Germany (346) and the world average of 113.[20] About 75 per cent of industrial robots deployed in Singapore are in the electronics industry. This high robot density is partly driven by the country's limited supply of factory workers and partly by its policy supporting IA.

The low robot density in most ASEAN countries suggests room for further adoption of industrial robots, especially in Member States that are experiencing shortages of labour supply and increasing costs. The disruption of manufacturing activities due to the impact of the COVID-19 pandemic could encourage firms (foreign and local) to accelerate adoption of automation to achieve a more resilient production system (McKinsey, 2020). Government policy that encourages automation is another factor. Increased adoption or demand for robots could encourage production of robots by IA MNEs in the region.

During 2016–2019, industries in Singapore, Viet Nam and Thailand installed the most industrial robots in the region (table 3.16). The annual pace of robot installation in Indonesia and Viet Nam is rising despite the low-cost labour environment in these countries.

In 2017, Viet Nam saw a surge in installation of industrial robots in the electronics industry (7,080 units) and adoption of automation by foreign and local companies in other industries. Traphaco, a local pharmaceutical company, opened an automated pharmaceutical plant in 2017. The plant deploys an advanced automation system using robotic arms.[21] In March 2018, Truong Hai Auto commenced operation of an advanced manufacturing plant involving a digitalization-based system and automation. The factory moved to intelligent production involving robots and smart workshops. Samsung's factories in Viet Nam use many industrial robots. At its production facility in Bac Ninh some 6,000 robots work on the assembly lines. VinFast, a local automotive manufacturer, opened an advanced manufacturing plant in 2019 involving IA technology and robots.

Table 3.15. Robot density in ASEAN, 2016, 2018 and 2019 (Number)

Country	2016	2018	2019
Indonesia	4	5	6
Malaysia	34	52	55
Philippines	4	4	5
Singapore	488	831	918
Thailand	45	51	54
Viet Nam	5	14	19
World average	**75**	**101**	**113**
Asia average	**69**	**103**	**119**

Source: International Federation of Robotics, as of 1 March 2021.
Note: Density measured by robots per 10,000 workers.

Table 3.16. Annual installations of industrial robots in ASEAN, 2016–2019 (Thousands of units)

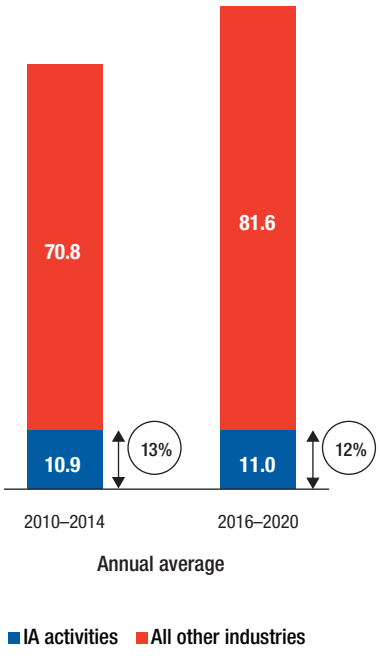
Country	2016	2017	2018	2019	2016–2019
Indonesia	1.0	1.0	0.8	0.7	3.5
Malaysia	1.9	2.9	1.9	1.2	7.9
Philippines	0.2	0.3	0.2	0.3	1.0
Singapore	2.6	4.6	4.3	2.3	13.8
Thailand	2.7	3.4	3.3	2.9	12.3
Viet Nam	1.6	8.3	1.6	2.2	13.7

Source: International Federation of Robotics, as of 1 March 2021.

3.4.2. FDI in industrial automation

Investment in activities related to IA in ASEAN is small. The value of announced greenfield investment in such activities was flat, at an annual average of $11 billion in 2010–2014 and 2016–2020 (figure 3.2).[22] Such investment accounted for about 12 per cent of total greenfield investment in ASEAN in the last decade.

Figure 3.2. ASEAN: Announced greenfield investment in activities related to IA, annual average 2010–2014 and 2016–2020 (Billions of dollars)



Source: UNCTAD.
Note: Includes activities related to manufacturing of electronics, electrical equipment, semiconductors, machinery and equipment, and to information and communication. In manufacturing, IA investors produce hardware products such as automation machinery, sensors, robots, switch gears, circuit breakers, contactors, protection relays, and electronics parts and components for automation. IA investors also provide services such as technology solutions, innovation hubs, centres of excellence and training.

MNEs producing IA hardware and software have been active investors in the region. Some have set up manufacturing facilities to supply IA equipment and develop customized production platforms for clients. ABB (Switzerland) manufactures switchgears for use in IA and power grids in the region. It has manufacturing facilities in Indonesia, Thailand and Viet Nam. In 2014 it opened a regional robotics packaging application hub in Singapore to develop hardware and software robotics manufacturing solutions for clients in the food and beverage, pharmaceutical, consumer electronics and solar photovoltaics industries. In 2018 it opened a robotics technical and service centre in Viet Nam to support customers in project implementation and to supply potential clients with advanced manufacturing technologies. Schneider Electric (France) has a smart factory in Batam, Indonesia for manufacturing power and IA products. In 2017 it opened a $45 million manufacturing plant in Viet Nam for the production of electronic products and wiring for smart homes.

Emerson (United States) opened an automation solutions centre at its Singapore regional headquarters in 2017. The centre uses advanced technologies, which include simulation and augmented and virtual reality applications. It demonstrates how automation and IIoT technologies can improve manufacturing processes. The centre marks the company's growing investment in automation technologies, services and engineering in the region. Rockwell Automation (United States) opened a connected services experience centre in Singapore in 2019. The centre demonstrates to customers the benefits of connected enterprise solutions and the integration of platforms for manufacturing. Honeywell (United States) has set up plants in Malaysia and Thailand to produce integrated automation solutions used in the aviation and electronics industries.

Table 3.17. Yamazaki Mazak: Industrial automation activities in ASEAN

Year	ASEAN country	Selected activities
1991	Singapore	Yamazaki Mazak Singapore Technology Centre
1992		Manufacturing plant with integrated computer system
1996		Machine tools manufacturing plant
2003	Thailand	Yamazaki Mazak Thailand Office and Technology Centre
2005	Singapore	Yamazaki Mazak Singapore manufacturing plant presents a cyberfactory concept
2009	Malaysia	Representative office of Yamazaki Mazak Singapore
2012		Malaysia Technical Centre
2013	Indonesia	PT Yamazaki Mazak Indonesia Technical Centre
	Viet Nam	Yamazaki Mazak Vietnam Technical Centre and showroom
2014	Singapore	Yamazaki Mazak Singapore South East Asia Technology Centre and factory expansion
2017		• Mazak I-Smart Factory • Additive manufacturing solution centre

Source: Yamazaki Masak.

Omron (Japan) launched an automation centre in Singapore in 2017. The centre functions as an innovation showroom and an R&D facility. It was part of the company's $10 million investment in robotics capabilities in that host country through 2019. Azbil Corporation (Japan) opened a solution and technology centre in Thailand in 2020. The centre has adopted the use of intelligent solution services using IIoT and AI technology. Yamazaki Mazak (Japan), which offers IA solutions and products (table 3.17), established an advanced manufacturing facility (I-Smart) in Singapore that specializes in the production of machining tools and high-precision numerical control centres and machining centres for computers. Its R&D centre creates high value added engineered solutions and system machines equipped with advanced

industrial technologies. Its technology centres are local bases for introducing IA technology and solutions to customers. They demonstrate the application of advanced industrial machines, offer advice on machining needs and provide training.

Investment projects related to IA in Southeast Asia concentrate in (i) construction of IA-related manufacturing facilities, (ii) expansion of production capacity by converting facilities into smart/connected factories, (iii) setting up robotic and automation solution centres in several ASEAN markets, and (iv) establishing centres of excellence to showcase Industry 4.0 technologies.

3.4.3. Upgrading of IA technologies by MNEs

MNEs in ASEAN are upgrading IA technologies in factories to improve the efficiency of their manufacturing operations (table 3.18). The upgrading of IA technologies by these MNEs is encouraging hardware and technology solution providers to establish a presence or expand in the region to be close to markets. Some IA hardware manufacturers (e.g. sensors, semiconductors, automation machines, robots) also upgrade their own production facilities with advanced IA systems. Bosch (Germany) invested $368 million during 2011–2018 to upgrade its facilities in Viet Nam, which include manufacturing facilities, a software development centre and an automotive engineering centre. Emerson (United States) has automated its manufacturing facilities in the region. In 2017, it invested $10 million to upgrade its compressor plant in Rayong by adopting additional automation technologies and other industrial technologies from third parties. It has continued to upgrade its air-conditioning manufacturing facilities in Thailand with automation to support the company's business expansion in Asia.[23]

General Electric (United States) opened an Asia digital operations centre in Singapore in 2017 to support GE's global information technology services and, as part of a larger strategy, to deliver IT and digitalization technology to companies across the group. GE has two smart factories in ASEAN, one in Singapore that focuses on aviation products and the other in Hai Phong, Viet Nam that focuses on renewable energy machinery and components (e.g. wind-turbine generators and electrical control systems) for export. These factories use advanced manufacturing technologies, digitization and data analytics to enhance productivity and quality. GE's regional expansion centres on upgrading IA technologies across its factories in the region instead of building new plants.[24]

Schneider Electric (France) opened a factory in Batam in 1991 that produces 11 lines of its power and IA products. The company has continued to upgrade the Batam factory. It partnered with Aveva (United Kingdom) to further digitalize the manufacturing process. By 2018, the Batam facility started to operate as a smart factory (section 3.6.2). In 2019, Schneider Indonesia transformed its Cikarang factory in Jakarta into an automated and connected factory that produces products for low- to medium-voltage electrical equipment.

Table 3.18. MNEs upgrade factories in ASEAN with advanced IA technologies

Company	Nationality	Facility/Location	Activity	Year
Bosch	Germany	Injection molding plant at Hemaraj Industrial Park, Thailand	Construction of a $95 million plant with smart factory technology and mobility solutions, including an R&D centre as part of the production facilities upgrade	2017
		Dong Nai manufacturing plant for propulsion belts	Transformation of the Dong Nai plant to include $71 million smart manufacturing facilities	2018
		Semiconductor Test Centre, Penang[a]	Adoption of an automated manufacturing solution for production of semiconductor components and sensor testing, and plans to expand with R&D and training facilities for smart manufacturing	2019
Delta Electronics	Taiwan Province of China	Manufacturing facility, Thailand	Transformation of its production facility to use advanced manufacturing solutions, which include • 70 four-axis selective-compliance assembly robot arms, developed by parent company and shipped to the Thai plant • Smart machines using vision systems and sensors to automatically detect product defects	2017–2020
Hitachi Industrial Solutions	Japan	Smart factory hub for Southeast Asia (Lumada Centre), Thailand	Establishment of centre to market factory solutions using the IoT to manufacturers throughout Southeast Asia	2018
Mitsubishi Electric	Japan	A new company (MELCO Factory Automation Philippines)	Establishment of a company to expand and upgrade Mitsubishi Electric's factory automation business in the host country	2019
		Singapore-based Akribis Systems	Acquisition of an equity stake in Akribis to strengthen Mitsubishi's IA businesses by incorporating Akribis's linear servo systems into the technology portfolio and Mitsubishi's e-factory facilities	2019
		New Factory Automation Centre in Malaysia	Start of operations to strengthen servicing and support for Mitsubishi Electric's factory automation products in Malaysia and thereby facilitate expansion of the company's local business in factory automation systems	2021
Schneider Electric	France	Cikarang factory, producing electric panels for customers in and outside Southeast Asia	Upgrading of factory with fully integrated IA systems and use of renewable energy; digitalization of manufacturing to support precision in machine maintenance, reduce risk of accidents and improve product quality	2017–2019
Techman Robot	Taiwan Province of China	Techman Electronics' Thailand factory	Introduction of advanced automation technology, using Techman robots, cobots and software solutions to improve assembly and increase production efficiency	2020
Yokogawa Electric	Japan	Singapore and Thailand operations	Introduction of new business unit focused on enterprise resource planning solutions	2019
		All ASEAN countries	Introduction of new sensors for wireless IIoT solution	2020

Sources: Compagny websites, media and industry reports.

[a] Invest Penang, "Bosch Malaysia to set up new plant in Penang", 3 June 2020 (https://investpenang.gov.my/press-release-bosch-malaysia-to-set-up-new-plant-in-penang).

3.4.4. Industrial automation players

MNEs are key players in IA in ASEAN, as investors, users and suppliers. They invest in manufacturing IA hardware equipment and in supplying technology solutions. They establish IA sales and distribution subsidiaries or offices, including centres of excellence, innovation hubs and R&D facilities. In some cases, they expand their presence in ASEAN by establishing IA centres and innovation hubs to support and offer customized solutions to clients. These business functions require establishing a presence close to prospective clients and to provide after-sales services to customers. Some IA MNEs have also established skills development and training centres to support customers.

Subsidiaries of global automotive, electronics and other industrial companies have automated their factories in ASEAN to achieve production efficiencies by adopting advanced technologies (box 3.6). IA helps these companies optimize plant capacities in line with production and control processes established by their parent organizations.[25] For example, in 2019 Yokogawa (Japan) established business units at its Singapore regional headquarters and a subsidiary in Thailand to provide manufacturing engineering solutions to customers in the region.

Box 3.6. MNEs and factory automation in ASEAN

Toyota Motor Manufacturing Indonesia, a subsidiary of Toyota Motor Corporation (Japan), has five production plants. Toyota's experience with IA and robotics technology in Japan led it to introduce mass automation in its manufacturing plants in Indonesia and its other production facilities in ASEAN. In 1996, Toyota established a plant in Karawang with a fully integrated automated vehicle manufacturing facility. In 2011, Toyota Corporation introduced a collaborative manufacturing concept, which used Industry 4.0 technologies (such as a digitalization system covering the application of IIoT, AI, digital connectivity, and data analytics) in Japan; its subsidiary in Indonesia followed suit (box table 3.6.1).

Box table 3.6.1. Toyota Motor Manufacturing Indonesia

Toyota manufacturing plants in Indonesia automated under varying timelines and with different advances in automation:

1970s	Mass automation since establishment in Indonesia
1996	Fully integrated and automated Karawang plant
1995–2010	85 per cent IT coverage on entire facility (including administration and operations)
2014–2016	Enterprise resource planning, process-based structural reforms including use of robots
2017	Introduction of IIoT, robotic process automation and AI
2018	Introduction of blockchain, IT piloting, predictive maintenance technology
2019	Adoption of technology to support supply chain traceability
2021	Adoption of a data-driven culture. Continued expansion of the use of Industry 4.0 technology, including digitalization of human resources and skills building (e.g. improving employee analytics capability)

Source: Toyota.

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Box 3.6. MNEs and factory automation in ASEAN (Concluded)

Siam City Cement (Thailand) has upgraded its factories to increase efficiency and productivity. Fujitsu (Japan) has provided technology and solutions to these factories. Fujitsu upgraded one of these cement factories in Saraburi Province with advanced manufacturing technology and digitally connected the plant, which involves real-time monitoring of operations and preventive maintenance solutions. Siam City Cement started its digital transformation in 2017 with the Saraburi operation, shifting to an advanced digital factory or "smart connected factory" that connects people, processes and machines. This factory environment facilitates data collection and the use of data analytics and helped speed up decision-making processes. The connected factory has five key elements: (i) digitally connect the entire plant (with a high degree of automation), (ii) deploy mobile devices for inspection patrols, (iii) integrate information and operational technologies, (iv) create a system to manage vendors and information, and (v) establish a remote operation centre.

PT JVC Electronics Indonesia, a subsidiary of JVCKenwood (Japan), manufactures electronics and entertainment products in Indonesia. It has deployed cobots from Universal Robots (Denmark) in the production of audio-visual and navigation devices for cars. The JVCKenwood group is also adopting the use of Universal Robots cobots in the group's factories in Malaysia and Thailand.

Proton, a Malaysian automotive company, started production at its Tanjung Malim plant in 2004. The manufacturing and assembly facility at the plant initially had 180 robots. The plant continued to be upgraded with automation and can now assemble vehicles on three production platforms.

Sources: Company websites, industry reports and media.

(a) Top 50 global MNEs in industrial automation

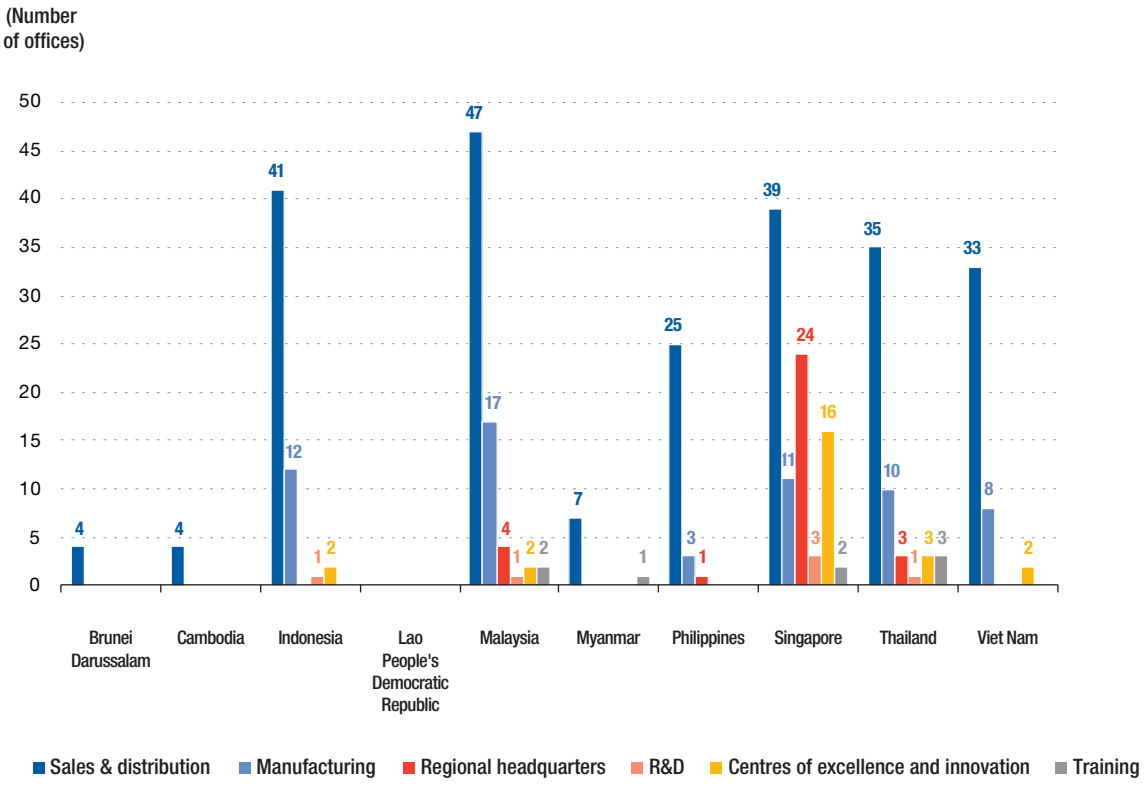
All of the top 50 IA MNEs in the world have a presence in ASEAN, which underscores the importance of the region for the IA business (annex table 3.1, figure 3.3). Most have extensive facilities with different business functions, from sales and distribution, to manufacturing, to centres of excellence to R&D activities. These MNEs operate, on average, in four or more ASEAN countries.

Most of the top 50 have multiple offices, primarily for sales and distribution. Some have IA manufacturing facilities in the region, mainly in Indonesia, Malaysia, Singapore and Thailand. These facilities produce parts and components, including machines, for IA. For example, Schneider has a factory in Batam that produces 11 lines of power and IA products such as sensors, switches, circuit breakers, contactors and protection relays. In many cases, these MNEs also use local distributors, dealers and system integrators to supply IA products and solutions to other manufacturers in ASEAN, including SMEs.

Malaysia, Indonesia, Singapore, Thailand, Viet Nam and the Philippines, in that order, host the most sales and distribution offices of these MNEs. The presence of a large number of foreign production facilities in these countries, particularly in the electronics and automotive industries,

are primary factors for the establishment of these offices. IA-related manufacturing facilities of these MNEs concentrate in Malaysia, Indonesia, Singapore, Thailand and Viet Nam because of the strong industrial clusters in those ASEAN countries.

Figure 3.3. Top 50 IA MNEs in ASEAN, by distribution of business functions (Number of offices)



Source: Annex table 3.1.

A majority of the top 50 regional headquarters, R&D centres and centres of excellence are in Singapore. Some regional headquarters or subsidiaries are responsible for channeling investment to other ASEAN Member States through their operations in that host country. For instance, a Singapore subsidiary of Sick AG (Germany) established representative offices in Indonesia and Viet Nam, and a subsidiary of Harting (Germany) invested in Indonesia and Malaysia. Turck (Germany) established a subsidiary in Singapore to oversee sales in Indonesia, Myanmar, the Philippines and Viet Nam. MKS Instruments (United States) has a sales and service office in Singapore, which also covers sales activities in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Some MNEs are also using Thailand as a platform to reach out to manufacturers in the Mekong subregion, primarily in Cambodia, the Lao People's Democratic Republic and Myanmar (the CLM countries). These MNEs include Beckhoff (Germany),

B&R Automation (Austria) and Yokogawa (Japan).[26] Other IA MNEs such as Beckhoff (Germany), Hitachi (Japan), Siemens (Germany) also use their operations in Thailand to oversee or develop sales and distribution activities in the CLM countries.

The top 50 MNEs are mainly from Europe (25, of which 15 from Germany), followed by the United States (15) and Japan (9). They are mostly major conglomerates in engineering, industrial systems and electronics. These MNEs include ABB (Switzerland), Honeywell (United States), Panasonic (Japan), Schneider Electric (France), Siemens (Germany) and Yokogawa (Japan). On average, they have a presence in four or more ASEAN countries (mostly in Singapore, Malaysia, Indonesia, Thailand and Viet Nam). Singapore and Malaysia have the most sales and distribution offices, manufacturing facilities, centres of excellence and regional headquarters.

Among the top 50, European MNEs (particularly conglomerates such as Siemens, ABB, Schneider Electric and Bosch) have an extensive presence in the region through a combination of multiple manufacturing facilities, sales and distribution offices, regional headquarters, R&D centres and training facilities. Siemens (Germany) has five IA-related manufacturing facilities in the region (Indonesia, Malaysia, Singapore and Viet Nam). It has an advanced manufacturing transformation centre, a digitalization hub and a consultancy for digital factory manufacturing design in Singapore as well as a digital industry academy in Viet Nam. Other European MNEs that have highly specialized operations have offices in three or more ASEAN countries but do not have manufacturing facilities. For example, Endress + Hauser (Switzerland) has offices in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam and a regional office in Singapore. Phoenix Contact (Germany) has sales subsidiaries in Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam and a regional headquarters in Singapore. Festo (Germany) has offices in Malaysia, the Philippines, Singapore and Thailand and a regional hub in Singapore.

MNEs from the United States tend to focus more on establishing sales and distribution offices in ASEAN countries and regional headquarters, mostly in Singapore. Examples are Fortive, Ropert Technologies, Mettler-Toledo, Belden and Teledyne Instruments. Some, such as National Instruments, Ametek, MKS Instruments and Baker Hughes, have one or two manufacturing facilities in the region. A few large business groups (e.g. GE, Rockwell Automation, Emerson, Honeywell, Flowserve) have a physical presence (in a range of business functions) in at least four ASEAN countries.

Japanese MNEs (e.g. Hitachi, Mitsubishi Electric, Yaskawa, Yokogawa, Azbil Group, Omron, Fuji Electric, Horiba) are mostly members of groups of companies. They follow the European MNEs' pattern, with a physical presence in five ASEAN countries on average, and operations in a range of business activities (e.g. sales and distribution, technical centres, manufacturing facilities, regional headquarters).

Many of the top 50 MNEs have been in ASEAN for a few decades, and they continued to expand regionally. They are also increasing their presence in the CLM countries and Viet Nam (the CLMV countries). Panasonic (Japan) established Factory Automation Group Panasonic

Vietnam in 2006 to provide automation solutions and service support for customers. In 2015 it established a business innovation centre, which supports customers for the entire manufacturing process and provides solutions for Industry 4.0 transformation. In December 2020, Rockwell Automation (United States) launched an automation laboratory in Viet Nam. The facility was established in partnership with Can Tho University (Viet Nam) to support the development of technical and engineering skills in automation.[27]

Some of the top 50 are also investing in Cambodia and Myanmar through training programs, authorized dealerships and representative offices. These MNEs include Siemens (Germany), ABB (Switzerland), Schneider Electric (France), Rockwell Automation (United States), Endress + Hauser (Switzerland), Phoenix Contact (Germany), GE (United States) and Fuji Electric (Japan).

Rapid manufacturing growth and burgeoning IA business opportunities are key drivers attracting the top 50 to invest and expand in the region. The presence of a large pool of manufacturers such as in the automotive and electronic industries has also influenced their location choice. Yokogawa and Fanuc (both Japan) have operations in ASEAN Member States that have a dynamic and growing manufacturing industry. Proximity to market and the need to demonstrate the use of IA technology, including through training, have led many to set up skills development or demonstration centres in key ASEAN Member States.

(b) Other major MNEs in industrial automation

IA companies that are not in the top 50 nonetheless have significant operations in the automation business in ASEAN. Most of these companies have sales and distribution offices in multiple ASEAN countries. Some have manufacturing and R&D facilities in the region. In some cases, these companies also adopted in-house IA technologies to upgrade their own production plants in the region. Larsen and Toubro (India) has a manufacturing facility in Singapore through a joint venture with Komatsu (Japan). Panasonic (Japan) manufactures resistors, sensors, switches and capacitors in Malaysia; sensors and semiconductors in Thailand; and industrial devices in Viet Nam. Toshiba (Japan) manufactures power automation devices in Malaysia; information equipment and semiconductors in the Philippines; semiconductors in Thailand; and industrial products, transmission ad distribution systems in Viet Nam. Some of these IA companies specialize in IA machines and hardware (e.g. sensors, measuring systems, laser markers) or robotics. Examples include Universal Robots (Denmark), Keyence (Japan), Yamazaki Mazak (Japan) and Setex (Germany).

Delta Electronics (Taiwan Province of China) has an R&D facility in Singapore and a manufacturing operation in Thailand. In 2014, it started to invest heavily in Southeast Asia to expand its system integration and IA solution businesses. In expanding its production activities in ASEAN, Delta adopted in-house IA solutions in its own factories. Yamazaki Mazak (Japan) has a strong presence with a smart factory in Singapore, and technical and technology centres in Indonesia, Malaysia, Thailand and Viet Nam. Keyence (Japan) has sales offices in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Other companies such as B&R

Industrial Automation (Austria) and Danaher Industrial (United States) provide a wide range of IA solutions to several industries. Danaher is a large corporation with several subsidiaries focused on a specific automation solution, whereas B&R Industrial Automation (Austria) is part of the conglomerate ABB (Switzerland).

(c) Similarities and differences of major players

Industrial automation MNEs in ASEAN can be divided into two types: end-to-end solution providers and specific solution providers (table 3.19). There are similarities and differences between them, particularly in their structure of operation, mode of entry and target markets. Most end-to-end IA solution providers are part of a large MNE group and as such, they have a ready market for their technology such as through intrafirm and parent-company business networks. For instance, Mitsubishi (Japan) provides in-house IA technology solutions to its automotive manufacturing business segment in ASEAN. Schneider (France) and GE (United States) are other examples. In contrast, specific or stand-alone IA technology providers do not have an organic market. They are more conservative in their expansion in ASEAN, often beginning with representative offices and authorized distributors rather than greenfield investments in manufacturing facilities or establishment of centres of excellence, which require large investment outlays.

Table 3.19. Types of IA technology and solution suppliers

Type of supplier	Organizational structure	Type of presence in ASEAN	Selected MNE or company
End-to-end IA technology solution providers (involved in automation and robotic technology hardware as well as software, with manufacturing facilities in the region)	Often members of a global MNE group with a portfolio of multiple businesses	• Sales and distribution subsidiaries or offices, manufacturing facilities, representative offices, centres of excellence, technology centres and networks of authorized distributors • Regional headquarters for Southeast Asia or Asia-Pacific • Present in five or more ASEAN Member States (most)	ABB (Switzerland) Bosch (Germany) GE (United States) Hitachi (Japan) Honeywell International (United States) Mitsubishi (Japan) Panasonic (Japan) Schneider Electric (France) Siemens (Germany) Yamazaki Mazak (Japan)
Specific IA technology solution providers (with established manufacturing facilities in ASEAN outside of their home countries)	Stand-alone company focused on technology or automation business, not diversified corporations	• Sales and distribution subsidiaries and offices, a manufacturing presence and a network of authorized distributors. • Presence in two to four ASEAN Member States	Balluff (Germany) Cashco (United States) Danaher (United States) Eaton (Ireland) Festo (Germany) Keyence (Japan) Universal Robots (Denmark) Yaskawa (Japan)

Source: ASEAN Investment Report 2020–2021 research, based on annex table 3.1, industry reports and media.

IA technology suppliers from the United States are mostly global multinationals with a strong focus on industrial technology hardware and software for a wide range of industries such as manufacturing, aerospace, health care, power and energy and agriculture. European IA technology providers may be either part of a multinational or a stand-alone specialized company. Both types focus on industrial machinery or solutions business. For example, Siemens (Germany) provides industrial advanced technology solutions to the aerospace, food and beverage, machinery and plant construction, pharmaceutical, transportation and logistics industries. Turck (Germany) is an IA company that produces automation hardware such as sensors, interfaces and connectivity technology products. European IA providers have the most exposure in the region, with larger numbers of manufacturing facilities and centres of excellence, and R&D activities in several ASEAN countries. Japanese IA technology providers are similar to their European counterparts in terms of organizational structure. They are either a member of a group of companies or a highly specialized company. For example, Hitachi Industry Solutions provides digital technologies, industrial and IT automation solutions, to connect entire manufacturing operations. Azbil Corporation, a member of the Yamatake group, offers both hardware and software industrial technology solutions. Yaskawa manufactures and sells robots, cobots, AC servo drives and other industrial automation hardware. Their parent companies are highly diversified and are involved in different industries (e.g. automotive manufacturing, financial services, electronics, real estate, power, trade). The diversity of the parent company provides an internal market opportunity. Japanese IA technology suppliers have the greatest numbers of technical or automation centres in the region. Their location decisions are also influenced by the presence or absence of a large pool of other Japanese manufacturers in the host country.

(d) Cases of MNEs

Many European, Japanese and American IA MNEs have set up operations in ASEAN to provide hardware and solutions to other MNE and local companies (box 3.7). The cases in this subsection highlight links between some IA MNEs and their clients in ASEAN in industrial automation.

Box 3.7. MNEs are supporting local manufacturing companies with IA technologies

Many foreign IA companies have established a presence in ASEAN to supply automation solutions to an increasing number of local manufacturers. The following cases highlight the link between local companies and foreign technology suppliers:

Davao Union Cement Corporation (Philippines) was supplied by Siemens (Germany) with a portfolio of automation equipment and solutions, which included an automation system and digitalization of the main production and secondary processes in its cement plant.

/...

Box 3.7. MNEs are supporting local manufacturing companies with IA technologies (Concluded)

Meiko Trading and Engineering (Viet Nam), a printed circuit board manufacturer, installed cobots (collaborative robots that interact with humans) in its production facility, supplied by Universal Robots (Denmark). Adoption of cobots improved production efficiency and worker safety and moved repetitive and strenuous tasks previously done by workers onto machines.

Proton (Malaysia) and Accenture launched a project in 2010 to expand and improve Proton's SAP-based enterprise resource planning system, which included automation. Accenture worked with Proton to upgrade business processes across the company as a step to move further with advanced manufacturing solutions in the company's transformation process.

VinFast (Viet Nam), an automotive manufacturer, implemented Siemens' complete automation equipment for its manufacturing lines in all shops, from press to paint, body, sub-assembly and engine.

Vinamilk (Viet Nam) in its Bin Duong factory installed highly automated processing equipment and packaging lines and a plant integration system. Cartons are filled with processed dairy products on 17 packaging lines. Fifteen unmanned laser-guided vehicles move packaging and products around the factory following Wi-Fi instructions. An automation system from Tetra Pak (Switzerland) allows Vinamilk to run and control the entire plant from reception of milk to distribution. All production equipment is connected, so that the individual units can communicate with one another. Automation aids production scheduling and prevents unplanned downtime.[a]

Many other locally and foreign-owned factories in different industries in ASEAN have embraced automation and robot technology from the many IA MNEs based in the region. ABB (Switzerland) supplied and installed automation equipment and solutions for many customers in the region. For instance, in Indonesia, PT Bogasari, a major producer of wheat flour, adopted ABB's robots in the palletizing process to improve food safety, productivity and efficiency; PT Makassar Tene deployed ABB's robots in the palletizing process of its sugar mill to improve food safety, productivity and efficiency; and PT Indolakto, a major dairy company, implemented ABB's digitalization and automation technology (advanced robots) for smart manufacturing at its Purwosari factory in 2012. In Thailand, Thai Summit Group's auto parts plants in Ayutthaya and Rayong installed ABB's robots for arc-welding applications and the spot-welding process. The Thai company also installed ABB's robots with a press automation system for high-production press at its factory at Laemchabang Industrial Estate. Charoen Pokphand Foods' livestock feed factories installed a dedicated pallet robot technology, which enabled palletizing processes to be conducted faster and in shorter cycle times; Cosmos Brewery, a subsidiary of Thai Beverage, deployed ABB's pallet robot automation system for bottling beer; Mitr Phol Group's sugar plants and biomass power plant adopted ABB's automation technologies that enable total control of production processes and analysis of operational information to improve production control; and Siam Cement Group's plants used ABB's automation equipment, mobile applications and data analytics for better control of cement kilns and energy management.

Sources: Company websites, industry reports and media.

[a] Tetra Pak, "State of the Art." (https://www.tetrapak.com/content/dam/tetrapak/media-box/global/en/processing/technology-area-general/pasteurization/documents/Case-Tetra-Pak-Vinamilk_v1_hi.pdf)

ABB (Switzerland) operates in four global business areas (i.e. electrification, IA, motion, and robotics and discrete automation). It has sales and distribution offices in nine ASEAN countries and manufacturing facilities in Indonesia and Thailand. It has also established different types of digital centres, robotic hubs and automation solution centers in ASEAN (table 3.20).

Table 3.20. ABB: Industrial automation, robotic and digital centres in ASEAN

ASEAN country	Type of centre	Date	Activities
Indonesia	R&D centre	2019	Develops enterprise software solutions to help clients transform towards Industry 4.0
Malaysia	Robotics Digital Operation Center	2019	Provides cross-industry digital platform to customers to secure, integrate and aggregate their data for big data and predictive analytics, and analyse performance to increase productivity. Supports clients in ASEAN for adoption of ABB robots.
Singapore	Robotics Application Center	2010	Applies automation for picking, packing and palletizing to support clients in industries such as food and beverage, pharmaceutical production, semiconductors and photovoltaics.
Singapore	Regional Robotics Packaging Application Hub	2014	Hosts a platform to develop novel robotics manufacturing solutions and value added engineering solutions for manufacturing processes. Target industries include food and beverage, pharmaceuticals, consumer electronics and solar photovoltaics.[a]
Thailand	Robotic Application Center	2011	Provides robotic applications and robotic knowledge to entrepreneurs, public organizations and educational institutes. Helps increase awareness of stakeholders about using robots to improve efficiency in manufacturing.
Thailand	ABB Robotics Machine-Tending Limited	2017	Develops machine-tending robots to support production processes, such as to feed components to lathes or mills.
Viet Nam	ABB Robotics Technical and Service Center	2018	Targets global and local manufacturers in the northern region of Viet Nam. Provides cutting-edge robotics technologies and training facilities.

Sources: ABB website, media and industry reports.
[a] Packaging Gateway, "ABB opens robotic packaging centre in Singapore", 23 July 2014.

Daifuku (Japan) develops, manufactures and provides automation and logistics solutions. It has offices for sales, engineering, installation and services for material handling or automation systems in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Some of the company's automation projects in ASEAN appear in table 3.21.

Table 3.21. Daifuku: IA projects and clients in ASEAN

Client	Host country	Activities
KDDI Sankyu (Japan)	Singapore	Installed an automated pallet tracking system on incoming and outgoing cargo using passive tags, integrated into the customer's warehouse management system to make retrieval of cargo information easier.
KLIA2 Kuala Lumpur	Malaysia	Designed and installed an automated baggage handling system with reports and analysis system that helps maximize efficiency and enable live bag tracking.
Indomaguro Tunas Unggul	Indonesia	Installed an automated freezing warehouse for a major fish processing company, which enabled thorough control of temperatures and improved inventory management.
Nusantara Parkerizing (Japan–Indonesia)	Indonesia	Installed an automated warehouse at Nusantara Parkerizing's surface treatment agent production base. The client provides automation parts and components for the automotive industry in Indonesia.
SATS	Singapore	Designed and installed an automation system to track the location of cargo in the Airfreight Terminal using radio frequency identification technology.
Sumitomo (Japan)	Singapore	Designed an automated bin tracking system for Sumitomo to track incoming and outgoing cargo at its plant.

Sources: Company website, industry reports and media.

Fanuc Corporation (Japan) provides industrial robots and factory automation machines in the region since 1979. It established sales and services centres in more than six ASEAN Member States (e.g. Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam) where Japanese manufacturing facilities are mostly located.

Rockwell Automation (United States) is a major producer of IA and digital technology. It has a presence in six ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam). It supplies IA technology solutions mainly through commercial offices and a network of local distributors. It offers training activities in the six countries and has a regional office, including a manufacturing facility, in Singapore. The company is also working with ZI-ARGUS (Australia), an IA and process control solution provider, in the region. Many manufacturers and OEMs in ASEAN (e.g. PSB Corporation and Integral Systems) uses Rockwell Automation controller solutions.[28]

Siemens (Germany) provides automation products and solutions that include IA systems, motion control systems, system cabling and process control. It has other automation value chain operations in addition to sales and distribution offices in nearly all ASEAN countries (table 3.22).

Table 3.22. Siemens: IA activities in ASEAN

Country	IA activities (Selected cases)
Indonesia	• A manufacturing facility for smart infrastructure and distribution systems • With Bentley Systems, installed a petrochemical digital twin for Chandra Asri, Indonesia's largest integrated petrochemical complex, presenting a virtual version of the plant and supporting analysis of engineering data
Malaysia	• Two manufacturing facilities for semiconductors • Supplied IT infrastructure and process automation systems to Infineon's semiconductor plant in Malaysia in 2005 • Installed a smart automation baggage handling system at the International Airport in Kuala Lumpur in 2006 • Launched its first Southeast Asian Technical Competency Hub in Penang in 2019, which hosts the latest innovations in smart manufacturing, additive manufacturing, product simulation and testing, plant simulation and automation solutions and functions as an offshore development centre for global project delivery, an R&D centre and industry-specific project consultancy, as well as a digital technology and automation project implementation facility[a]
Singapore	• A manufacturing facility, a consultancy entity for digital factory manufacturing design, a digitalization hub, an advanced manufacturing transformation centre • Launched a digital factory manufacturing design consultancy in 2016 to assist clients in assessing the state of their digital and industrial technology readiness • Launched the Siemens Digitalization Hub in 2017, offering clients IIoT and Industry 4.0 transformation solutions • Launched the Siemens Advance Manufacturing Transformation Centre in 2020, providing support and training to clients for adoption of and transformation towards the use of advanced manufacturing systems[b]

Thailand	• One office, which also oversees business development in Cambodia and Myanmar
	• Selected clients for IA in Thailand:
	  ○ Sammitr Motors Manufacturing (Thailand), which supplies parts for dump trucks, trailers and semi-trailers and accessories for pickup trucks
	  ○ Material Automation (Thailand) (a Japanese subsidiary), which provides IT solutions to Japanese manufacturers in Thailand and joined the Siemens Solution Partner Program to serve third-party clients.
	  ○ Packsys Global Thailand (Switzerland), for which Siemens installed a motion control system to manufacture specialty machines
	  ○ Siam City (Thailand), for which Siemens installed process automation in a cement plant

Viet Nam	• A factory for automation products, a digital industry academy • Some customers: include VinFast (Viet Nam), Sabeco (Viet Nam), Coca-Cola (United States), Heineken (Netherlands), Samsung (Republic of Korea), TetraPak, Grob-Werke (Germany)

Sources: Company websites, media and industry reports.

[a] MaxIt, "Siemens launches technical competency hub in Penang", June 2019; Frontier Enterprise, "Malaysia hosts Siemens lone technical competency hub in SE Asia", 30 June 2019.

[b] *Industrial Automation Asia (iaasiaonline),* "Siemens launches advanced manufacturing competence centre in Singapore", 10 September 2020.

Universal Robots (Denmark) provides robotic technology accessible to SMEs. In 2015, the company established its regional headquarters in Singapore. It has been providing collaborative robots (cobots) to companies based in Southeast Asia through its network of distributors in the region. In the Philippines in 2016, it partnered with Asia Integrated Machine to supply robotic technologies to MNEs and local companies such as Nestlé (Switzerland), Unilever (United Kingdom) and Jollibee Foods (Philippines). It entered the Malaysian market in 2013 through TT Vision Technologies, a local systems integrator. Universal Robots partner with the Malaysian company to develop automated solutions for high speed production line end-users. It has also expanded its network of distribution partners in Malaysia. Other Malaysian distributors include DF Automation, EPCO Precision and TMS Collaboration. In Viet Nam, its distributor and system integrator partners include Servo Dynamics Engineering and Tan Phat Automation. In 2019, the company launched a training centre for the use of robots at its regional headquarters in Singapore.

Yokogawa Electric (Japan) has been involved in IA, control and measurement products and solutions in ASEAN since 1974. It has a presence in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. In Indonesia, it established a manufacturing operation (Batam) and in Singapore a development centre for production control application software. The large and growing pool of Japanese and other manufacturing companies in ASEAN influenced the company's expansion in the region. In 2019, Yokogawa established business units at its Singapore regional headquarters and a subsidiary in Thailand to provide manufacturing engineering solutions to customers. The company's new operations provide IT, plant automation and control technology solutions to industrial customers.

3.4.5. Emerging players

New players are emerging from other sources – from China, the Republic of Korea and Taiwan Province of China. Industrial robots from Chinese, Korean and Taiwanese companies are making inroads into ASEAN's IA and robotic technology market. These emerging players are attuned to the needs of the Asian market in terms of creating robot-human interface solutions to balance automation needs with the availability of cheap labour. Their designs and manufacturing technology have developed over the years with strong government support and clear national plans to promote robotic innovation.[29]

While traditional IA MNEs established a presence in ASEAN in the 1970s–1980s, emerging players have entered ASEAN markets more visibly since the 2010s. In contrast to traditional MNEs, emerging players serve clients in ASEAN mostly through local distributors and as system integrators. For instance, among companies from Taiwan Province of China, Techman Robot has an extensive network of distributors in ASEAN and an electronics factory in Thailand, and Fatek Automation offers IA hardware and software solutions through authorized distributors (e.g. Alstron (Singapore)) that also cover markets in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam.

(a) Korean IA companies

Leading Korean MNEs (mostly subsidiaries of conglomerates) provide IA technologies and smart factory solutions to Korean and other clients located in ASEAN (box 3.8). These subsidiaries include Doosan Machine Tools, Doosan Robotics, Hyundai Robotics, Posco ICT, LG CNS and Samsung SDS. They also operate as systems integrators in smart factory solutions to upgrade manufacturing plants in their groups of companies. Some have recently expanded into providing industrial transformation solutions and services to third party customers.

Box 3.8. Korean companies: FDI in IA and smart factory solutions in ASEAN

Hyundai Motors is constructing the Hyundai Mobility Global Innovation Centre in Singapore, to be completed by 2022. The centre will include a smart factory to support innovations for future mobility. It is also a test centre for developing intelligent manufacturing platforms. It will have interconnected advanced industrial technologies, such as sensors, IIoT to gather real-time data, AI to analyse data and digital systems to instruct production robots. Hyundai Motors is also building its first ASEAN manufacturing plant in Indonesia, to be completed in 2022. The plant, with a smart factory environment, will have technologies for automatic recognition of car types and specifications, real-time equipment inspection and preventive diagnostics. Hyundai Robotics, established in 2020, will supply 370 vehicle manufacturing robots and peripherals to the Indonesian plant.

Samsung SDS, a digital entity of the Samsung Group, acquired a 25 percent stake in 2019 in CMC Corporation, a leading IT firm in Viet Nam. The joint venture aims to expand the partners' business beyond smart factories, cloud computing and cybersecurity.[a] Samsung SDS will combine its strength in AI, big data and IIoT technology with CMC's local business network and brand to serve Viet Nam's growing manufacturing industry.

In March 2020, *Samsung Electronics* started construction of a $220 million R&D centre in Hanoi, Viet Nam. The centre, to be completed by 2022, will be the largest in Southeast Asia and will enhance the company's research capabilities in areas such as AI, IoT, big data and 5G technology.[b]

LG CNS, an LG Group affiliate that provides system integration, is expanding in ASEAN in smart parcel distribution system solutions. It installed an automated system in 2020 for Malaysia's parcel delivery service provider PosLaju.[c] LG CNS provided all equipment, including an automatic cross-belt sorter system to replace the manual system.

Hyosung TNC transformed its Spandex production plant in Viet Nam with advanced IA systems and IIoT technology. The upgraded factory maintains better quality control by monitoring real-time production status. The digital technologies also facilitate data collection and analysis and management control in the entire manufacturing process, from import of materials to production and shipping.

Zin Corporation, an SME, is a smart factory technology solution provider. It has subsidiaries in Thailand and Viet Nam. It opened a smart factory showroom in Thailand in 2018 and completed construction of an automated logistics facility for a large Korean duty-free distribution centre in Da Nang, Viet Nam in 2019.

Hyundai Mobis, an auto parts manufacturer, opened a data-mapping centre with a local company in 2017.[d] The centre, equipped with advanced digital technologies, is expected to promote development of autonomous cars.

Sources: Company websites, media and industry reports.

[a] *Pulsenews*, "Samsung SDS to acquire 25% stake in Vietnamese IT service firm CMC", 28 May 2019.

[b] *Industrial Automation Asia*, "Samsung constructs US$220 million R&D centre in Vietnam", 4 March 2020.

[c] *Korea Times*, "LG CNS sets sights on logistics automation", 22 November 2015.

[d] *Korea Herald*, "Korea businesses venture into ASEAN in search of new opportunities, 15 October 2018.

Aside from Korean conglomerates, the number of Korean firms providing IA and Industry 4.0 solutions in ASEAN is limited. However, in recent years more Korean firms have indicated interest in venturing into ASEAN's Industry 4.0 markets because of the growing pool of manufacturers, including Korean companies, in the region, and the policies of ASEAN countries promoting Industry 4.0 transformation. Smaller Korean IA companies such as Ahnlab (2014) and Samick (2016) have invested in ASEAN more recently. In 2019, 45 Korean companies exhibited Industry 4.0 technologies, covering green cars to smart factory solutions, at the ASEAN-ROK Innovation Showcase 2019 in Busan.[30]

(b) Chinese IA companies

Chinese IA companies have been emerging in ASEAN. For instance, in 2015 Dings Precision established a notable physical presence in the region, followed by Kuka Robotics (2016), Dobot (2017) and HikRobot (2018). Other Chinese automation companies also have a presence in ASEAN (e.g. Xinje, Youibot, Supcon).

Siasun Robot & Automation signed a memorandum of understanding with Thailand's National Science and Technology Development Agency in February 2021, to jointly develop an innovation centre in Thailand. The centre will develop automation, robotics and intelligent systems. In 2020, Siasun partnered with Somboon Advance Technology, a major Thai maker of auto parts and machinery, to provide full system integration services to the automotive and auto parts industries in the country. It also established a subsidiary in Singapore in July 2017 to serve the Asia-Pacific market. In a Singapore factory of Becton Dickinson (United States), Siasun installed an intelligent logistics system, which carries out delivery, sorting and palletizing of finished medical devices.[31]

A subsidiary of *Kuka* (headquartered in Germany but owned by Chinese Midea Group) provided robot-based intralogistics solution at IKEA Supply in Malaysia and palletizing robots to Gopeng Kalsium, a Malaysian SME. Kuka has established a strong presence in ASEAN with a regional headquarters and a one-stop training centre (Kuka College) in Malaysia, and sales and service offices in Singapore, Thailand and Viet Nam. Through its subsidiary, Swisslog (Switzerland), it offers end-to-end robotic and automation solutions to companies in ASEAN. Swisslog Singapore handles sales and services in Indonesia and the Philippines.

Yuejiang and Beijing Canbot Technology are partnering with the Malaysia Artificial Intelligence & Robotic Association to help stimulate the development of local robotics companies.

(c) Foreign distributors

The involvement of foreign companies in IA in ASEAN is not limited to OEM-MNEs supplying IA hardware and software to manufacturing clients. It also includes foreign IA companies that do not own their own brands but extend systems integration services or act as distributor agents for IA OEM-MNEs (table 3.23). These foreign distributors partner with major IA and robot technology suppliers (in hardware and software solutions) to serve regional clients.

Table 3.23. Foreign IA technology distributors and agents in ASEAN (Selected cases)

Company	Headquarters	Location	Foreign technology partners	Customers in ASEAN (Selected cases)
Aberle Automation	Germany	Thailand	EFS Festo Rexroth Bosch Rofa Sickert & Hafner Siemens (all Germany)	Baumann Automation (Mercedes Benz) BMW Manufacturing Continental Design Group SA Thonburi Automotive Assembly Plant Toyota
ITO	Japan	Thailand	Eaton Corporation (United States) Yaskawa (Japan) Yokogawa (Japan)	..
PT Kaizen Automation Indonesia	Japan (joint venture with a local partner)	Indonesia	Allen Bradley (United States) Mitsubishi (Japan) Omron (Japan) Rockwell Automation (United States) Schneider Electric (France) Siemens (Germany)	PT Astra Daihatsu Motor PT Honda Prospect Motor PT Suzuki Indo Mobil
Thai Rokuha	Japan	Thailand	ABB (Switzerland) Fanuc Robots(Japan) Mitsubishi(Japan) Nachi Robots (Japan)	Aisin AI Alps Tool Honda Trading Asia K-Thai Hydraulic Ogura Clutch Sankin Tanaka Precision Thai Kikuwa Industries OTC Diahen Asia San-Ei Sunstar Engineering Yarnapund
PT Treesse Progetti	Italy	Indonesia	Copadata (Germany) Invensys Wonderware (United Kingdom) PILZ (Germany) Schneider Electric (France) Siemens (Germany)	Bali Hai Brewery

Sources: Company websites, industry reports and media.

(d) Partnership with local distributors

IA MNEs also access the ASEAN market through business linkages and networks of authorized local distributors, which provides deeper penetration into the ASEAN market for IA providers both with and without manufacturing facilities in the region. Rockwell Automation has a network of authorized distributors in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam; Bosch has local sales and service partners in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Universal Robots formed a partnership with Asia Integrated Machine (Philippines) to support the increasing use of robots in the electronics, automotive,

and food and beverage industries in the Philippines, and B&R Industrial Automation has a network of local dealers in many ASEAN Member States (table 3.24). In Malaysia, Comau Robotics & Automation (Italy) partnered with DNC Automation, a local distributor.

Some local automated system integrators and IA distributors have grown to become regional companies. For example, Singapore-based companies such as Astech, with operations in Malaysia and Thailand (through a joint venture with Thai-based Sumipol); Pumas Automation and Robotics operating in Malaysia, the Philippines and Viet Nam; Servo Dynamics in Malaysia, Thailand and Viet Nam; TDS Technology in Indonesia, Malaysia and Thailand; Lin Wah Engineering Works with offices in Indonesia and Viet Nam; and Factronics Systems Engineering in Malaysia and Thailand.

Table 3.24. B&R Industrial Automation network of authorized local dealers in ASEAN

Country	Dealer	Other brands carried	Customers
Indonesia	PT Indo Mandiri Sentosa (established 2001)	Brainchild (Taiwan Province of China) Odawara Industry (Japan) Soshin (Japan) Toyo Denki (Japan)	Astra Daihatsu Motor (Japan) Freeport Indonesia (United States) Ichikoh Indonesia (Japan) Indah Kiat Pulp and Paper (Indonesia) Sumi Indo Kabel (member of the Sumitomo Group (Japan)
Thailand	Samut Sakhon: Industrial Technology Supply (established in 1993)	ABB Spirit Innovative Technologies (Switzerland–Sweden) Elutions (Control Maestro) (United States)	United Paper (Thailand)
	Min-Buri: PK Control Solution (established in 2021)	ABB Spirit Innovative Technologies (Switzerland) Elutions (Control Maestro) (United States)	Charoen Pokphand Food Haing Seng Fibre Container Johnson and Johnson Panjaphol Pulp and Paper Industry Siam VMC Safety Glass SmartTract Thainamthip Co Ltd Union Carton United Paper
Viet Nam	Duc Phong Technology and Automation Corporation (established in 2006)	ABB (Switzerland) Aimetis (Canada) Axis Communications (Sweden) EMC (India) Innodesk (India) Mutec (Germany) Pulse (Australia) Redlion (United States)	AbinBev Coca-Cola Heineken Vietna NB Steel Phusen Screw Conveyor Sabeco Suntory Pepsico THP Group Vicem Tam Diep Cement Akzo Nobel VNSteel Vicasa

Source: B&R Industrial Automation.

(e) Centres of excellence and IA technology centres

Many IA and robotic hardware and software MNEs have also established centres of excellence and robotic technology centres in key markets in the region to showcase services, develop customized solutions and provide training for clients (see section 3.6.1). Many did so to be close to manufacturing clients. Some of these MNEs have collaborated with government institutions and universities on IA skills development and training programmes (table 3.25). Some IA MNEs also operate in the IIoT segment and have established centres of excellence that cover both IA and IIoT solutions.

Table 3.25. Partnerships of foreign IA and robotic technology suppliers in ASEAN (Selected cases)

Company	Headquarters	Location in ASEAN	Partnership with	Reason for partnership	Year established
ABB	Switzerland	Malaysia	InvestKL	Conduct investment promotion and training	2019
Bosch Rexroth	Germany	Singapore	Jurong Town Centre Singaporean-German Chamber of Industry and Commerce Skills Future Singapore Singapore Polytechnic	Support skills development, including at the Bosch Rexroth regional training centre	2020
Emerson	United States	Singapore	Singapore Polytechnic	Develop human resources and conduct training	2017
Festo	Germany	Viet Nam	Schools and universities (Viet Nam)	Develop human resources and train specialists	2017
Mitsubishi Electric Asia	Japan	Singapore	Nanyang Polytechnic	Help develop capabilities and specialist skills in smart monitoring and AI technologies	2019
Mitsubishi Electric	Japan	Philippines	Integrated Factory Automation (Philippines) Setsuyo Astec Corporation (Japan)	Expand Mitsubishi Electric's factory automation business in the host country Manufacture linear servo motors	2019
		Singapore	Akribis Systems	Strengthen IA solutions and capacity for the global market	2019
Rockwell Automation	United States	Southeast Asia and global markets	Fanuc (Japan)	Develop complementary solutions based on Rockwell's automated integrated solutions and Fanuc robot technology	..
Siemens	Germany	Singapore	Skills Future Singapore	Conduct training progammes	2020
Toshiba	Japan	Viet Nam	FPT Vietnam	Help manufacturers to adopt integrated smart factory solutions	2018
Yaskawa	Japan	Thailand	King Mongkut's University of Technology, Faculty of Engineering	Conduct training and develop skills in robotics and technology	2020

Sources: Company websites, investment agencies, industry reports and media.

3.5. ADDITIVE MANUFACTURING

The market for additive manufacturing (AM) technology and equipment in ASEAN is currently small but is expected to grow rapidly over the next five years and beyond. AM spending in ASEAN was estimated at about $266 million in 2019 and is projected to reach $100 billion by 2025 (Thyssenkrupp, 2019). In perspective, that is about 5–7 per cent of Asia's AM market of $3.8 billion in 2019. By 2025, the AM market in ASEAN is expected to be about one third the size of the combined digital economy market of the six largest economies in the region (Google, Temasek and Bain, 2020).

ASEAN offers a huge market potential for AM given the increasing interest by manufacturers in adopting 3D printing technology and the region's expanding manufacturing base. Aside from manufacturing, AM has also been adopted in the aerospace, maritime and health care industries in the region, particularly in Malaysia, Singapore and Thailand. Demand for AM has been shifting from prototyping to industrial 3D printing of parts. This demand growth, government policy and institutional support, and other factors (e.g. the improving AM ecosystem in some Member States) have led to the growing presence of AM MNEs in ASEAN. The pandemic has also accelerated the adoption of AM technology (box 3.9).

Despite growing interest by local and foreign firms in AM, the market is highly concentrated. A few Member States attract proportionately more AM manufacturers and solution providers: in 2019 Singapore accounted for 40 per cent of the AM market value in ASEAN, and Thailand and Malaysia together accounted for another 40 per cent (table 3.26).

Table 3.26. AM market in ASEAN, 2019

Country	Share of ASEAN market size (per cent)	AM penetration	Stage of AM development
Singapore	40	Medium	Leading
Thailand	25	Low to medium	Emerging
Malaysia	15		Emerging
Viet Nam	6	Low	Early stage
Philippines	5		Early stage
Indonesia	4		Early stage
Cambodia	2		Potential
Brunei Darussalam	1		Potential
Lao People's Democratic Republic	1		Potential
Myanmar	1		Potential

Source: Thyssenkrupp (2019).
Note: AM penetration = country AM market size divided by manufacturing value added. Leading = >30% market share, emerging = 10–30% market share, early stage = 3–10% market share, potential = <3% market share.

Box 3.9. Application of AM technology in Southeast Asia during the pandemic

The pandemic paralysed production across many industries. Because AM offers a solution for building a resilient supply chain, the pandemic has accelerated the adoption of 3D printing solutions by many manufacturers.[a] In the automotive industry, BMW (Germany) has been using AM technology in its Rayong plant in Thailand. Beyond the pandemic, it plans to integrate AM more fully into local operations to allow small production runs, country-specific editions and customizable components.[b]

In the health care industry, AM has been used during the pandemic to produce emergency medical goods and other personal protective equipment. Critical devices for the health care industry – e.g. face shields, ventilators, COVID-19 test swabs – have been mass produced through the application of AM technology.[c] In Malaysia, 3D printing technology was used to manufacture medical devices to supply customers worldwide. These devices include bio-cellulose swabs, antibacterial bio-cellulose masks and test boxes. An example is antiviral bio-cellulose masks, which were 3D-printed using production facilities in Kuala Lumpur owned by Texas Instruments (United States).[d]

In Singapore, a consortium led by the National Additive Manufacturing Innovation Cluster and participated by the National University of Singapore, the National University Hospital, AM technology provider Formlabs (United States) and Eye-2-Eye (Singapore), a medical and dental technology distributor in Southeast Asia, developed and mass-produced swab test kits – about 30,000 swabs per day – using AM printers.[e] Siemens' Advance Manufacturing Transformation Centre, supported by Singapore's Agency for Science, Technology and Research, HP (United States) Smart Manufacturing Applications and Research Centre, and Mitsui Chemicals (Japan) collaborated to design and manufacture face shields using AM.[f]

In Thailand, the Vidyasirimedhi Institute of Science and Technology (Vistec) developed and produced a rapid test kit to identify COVID-19-positive patients, using 3D printing prototypes. The Vistec test is a joint research project by the Biomolecular Science and Engineering Faculty of Vistec, the Faculty of Medicine at Siriraj Hospital and the Faculty of Science at Mahidol University, with support from the Massachusetts Institute of Technology and Harvard University, as well as from private companies, including Siam Commercial Bank and PTT.[g]

Sources: Company websites and media.

[a] National Research Foundation, Prime Minister's Office, Singapore; based on an interview with Professor Chua Chee Kai: "Printing an arsenal of pandemic preparedness", in *Asia Pacific Metalworking Equipment News*, 2020.

[b] Manufacturing global.com, "BMW invests €10mn in a new additive manufacturing campus", 16 May 2020.

[c] 3DNatives, "What were the 3D printing trends of 2020?", 10 December 2020.

[d] NCBI, "Review on 3D printing: Fight against COVID-19", 22 October 2020 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7578746).

[e] Formlabs, "Eye-2-Eye Communications: Printing 30 000 swabs per day in Singapore", 26 October 2020.

[f] *Asia Pacific Metalworking Equipment News*, "Recap: Additive manufacturing deployments in Southeast Asia", 24 November 2020.

[g] *Bangkok Post*, "Frontline tech takes on Covid 19", 5 May 2020.

3.5.1. Additive manufacturing players

(a) Major global AM MNEs in ASEAN

AM MNEs in ASEAN can be identified as equipment manufacturers, solutions providers and different categories of industrial users (table 3.27). Many MNEs have also established regional headquarters, centres of excellence and R&D centres in the region to further develop industry-specific AM applications or to develop them for use in other industries. Some MNEs and local companies also develop alternative materials for 3D printing.

Table 3.27. Categories of AM players in ASEAN

Category	Activity	MNEs
End-to-end solution providers	Provide equipment/machine and solutions from design, prototype to production	GE Additive (United States) Shonan Design (Japan) SLM Solutions (Germany) Stratasys (United States)
Equipment manufacturers	Manufacture and supply AM machine and equipment	EOS (Germany) Formlabs (United States) HP (United States) Renishaw (United Kingdom) Ultimaker (Netherlands) Yamazaki Mazak (Japan) Sodick (Japan)
Material suppliers	Developers or suppliers of 3D printing materials	Evonic (Germany) Optomec (United States) Sandvik (Sweden)
Software solution providers	Provide software and technology solutions	CADFEM (Germany) Materialise (Belgium)
Users: contract manufacturers (OEMs)	Use AM equipment and technology to improve manufacturing efficiency	Jabil and Underwriters Laboratories (both United States) Ivaldi (Norway) Voestalpine (Austria)
Users: Large industrial users	With support from AM technology providers, develop and use specialized AM technology and equipment for own operations	DNV GL (Norway) GKN Aerospace (United Kingdom) Wilhemsen (Norway)

Source: ASEAN Investment Report 2020–2021 research, based on annex 3.2, industry reports and media.

Materialise (Belgium) established its Asia-Pacific R&D hub for AM in Malaysia, and New Kinpo Group (Taiwan Province of China) established a manufacturing and R&D facility for 3D printers in Thailand. In Singapore, GE Additive (United States) established its regional headquarters, HP (United States) its Asia-Pacific headquarters and an R&D facility, and Siemens Additive (Germany) its Advance Manufacturing Transformation Centre. Also in Singapore, Thyssenkrupp (Germany) opened its Additive Manufacturing TechCenter Hub and Sodick (Japan) opened its Techno Centre.

Many of the major global AM MNEs have established a presence in ASEAN (annex table 3.2). They include mostly AM MNEs headquartered in the European Union, Japan or the United States. These MNEs have distinctive characteristics in terms of organizational structure, business presence and mode of expansion. European-headquartered AM MNEs have a more extensive regional presence with a broader array of business functions. Most of these business functions (e.g. sales office, centres of excellence, regional headquarters and

R&D activities) are based in Singapore, which is also a key destination for AM MNEs from the United States and Japan. Other ASEAN Member States (e.g. Indonesia, Malaysia, the Philippines, Thailand and Viet Nam) are also important locations. AM MNEs from the United States are concentrated in fewer ASEAN Member States (primarily Singapore as regional headquarters), which are also used to oversee operations in the region. They have extensive networks of authorized representatives to serve the ASEAN market. AM MNEs from Japan are relatively more active in setting up technical centers and offices in ASEAN Member States where there are large numbers of Japanese-owned manufacturing facilities (e.g. Indonesia, Malaysia and Thailand).

Sales is the most common business function located in ASEAN for the major AM MNEs, followed by regional headquarters and centres of excellence. AM providers that are members of large MNE groups have established their presence in ASEAN through significant investment in AM activities, such as sales subsidiaries, regional headquarters, centres of excellence and R&D. These MNEs include GE Additive (United States), Hewlett Packard (United States), Materialise (Belgium), New Kinpo Group (Taiwan Province of China), Siemens Digital Industries ASEAN (Germany), Sodick (Japan), Voestalpine (Austria) and Yamazaki Mazak (Japan).

Smaller or independent AM companies tend to establish a presence by setting up a sales office or a regional headquarters (mostly in Singapore) or developing a network of authorized dealers. Such companies include Formlabs (United States), with an office in Singapore and a network of resellers in other ASEAN Member States; Markforged (United States), which partnered with Chemtron (Singapore), also its authorized distributor for clients in Indonesia and Malaysia; ORLaser (Germany), which appointed Eye-2-Eye Communications (Singapore) as its authorized distributor for markets in Indonesia, Malaysia, the Philippines, Singapore and Viet Nam; and Voxel Jet (Germany), which partnered with Cad Cast (Thailand) to expand in ASEAN.

(b) Local AM companies and start-ups

Most ASEAN AM players are authorized representatives, resellers and distributors for foreign AM MNEs. Some have expanded to include 3D-printing prototypes and have established teams of experts to work closely with clients. Their other services include design, testing and production. These ASEAN companies include 3D Solution (Indonesia), Zelda 3D (Malaysia), Pebblereka (Malaysia), 3D Printer (Malaysia) and Metro Systems Corporation (Thailand). Some have become large OEMs and provide end-to-end AM solution services to clients in various industries (e.g. manufacturing, health, aerospace, maritime, jewelry). They have also expanded regionally and to other parts of the world. These companies include 3D Metalforge (Singapore–United States), Chemtron (Singapore), Eye-2-Eye (Singapore), Harn Engineering Solutions (Thailand), Septillion (Thailand) and Structo (Singapore). ASEAN AM start-ups have also established important business linkages with MNEs, which entail technology support, funding and collaboration with foreign AM companies for the development of AM technology solutions and materials (table 3.28).

Table 3.28. Domestic AM start-ups in ASEAN (Selected cases)

Start-up	Headquarters	Activity	Association with MNEs and other foreign companies
3D Maker	Viet Nam	3D printer developing and manufacturing, 3D design and printing services	Partners with Misumi Corporation and TSK (both Japan) for technology solutions and equipment support
3D Matters	Singapore	End-to-end additive manufacturing solutions	Utilizes 3D printing software solutions from Rhinoceros 5 (United States), DS Solidworks (France), Autodesk (United States) and QuantAM (United Kingdom)
3dprint.id	Indonesia	3D printer manufacturing and CAD consulting	Has vendor-client relationship with the following companies: Selectrix (Australia) and Astra Honda Motor (Japan-Indonesia)
CBMTI	Malaysia	3D printing services for the health care industry	Uses 3D printing technology solutions provided by Stratasys (United States)
CraftHealth	Singapore	3D printing of personalized health care devices (using 3D printing technologies to simplify the process of taking pills)	Receives funding support from Mistletoe (Japan)
CreoPop	Singapore	Development of a pen-shaped 3D printer using resin ink	Utilizes the e-commerce platform of Amazon (United States) for marketing its products. Raised funding for expansion from 500 Startups (United States) and other venture capital firms
Ecomaylene 3D	Singapore	Development and manufacturing of 3D printers and 3D printing filament materials	Uses the e-commerce platforms of Amazon (United States) and Lazada (China) to market its products
Expedio Design	Malaysia	Industrial design and rapid prototyping	Materials supplied by Kraiberg (Germany) Services provided to many foreign companies, such as Ansell (Australia), Assa Abloy (Sweden), Dentsu (Japan), Isobar (Japan), Steelcase (United States)
Ima 3D Printer	Indonesia	Development of of 3D printers	Has vendor-client relationship with Mitsubishi Motors (Japan)
Imajin	Indonesia	Management of a 3D print marketplace where clients can choose a local manufacturer to create a product	Has vendor-client relationship with companies such as Showa and YKK (both Japan)
Inspira.Academy	Indonesia	Innovative tech learning ecosystem. Modules & tools combining 3D design-print, robotics, electronics and coding for innovators	Established technology collaboration with MakerBot (United States) and Einscan (China) for 3D training courses
Structo	Singapore	Development and production of industrial-grade 3D printers and materials	Established technology and R&D collaboration with pro3dure (Germany) and Materialise (Belgium) Vendor-client relationship with Best Smile Aligners (Switzerland).
Supercraft3d	Singapore	Additive manufacturing focused on health care applications	Raised funding from XponentialWorks (United States)
Treebuild	Thailand	Development of a marketplace and web application with 3D printing	Established collaboration in 3D printing hardware and software solutions with Shapeways (United States), Sketchfab (United States), MakerPoint (Netherlands)

Source: *ASEAN Investment Report 2020–2021* research based on Crunchbase, TracxN listings, company websites and media.
Note: Excludes start-ups owned by foreign MNEs.

(c) Partnerships and collaborations

AM MNEs engage in four types of collaborations in the region: (i) with host governments, (ii) with research or academic institutions, (iii) with other private sector providers and (iv) in joint ventures (table 3.29). Many AM MNEs in ASEAN, particularly those that have established regional headquarters, centres of excellence, training centres and R&D facilities, also collaborate with government agencies, research institutions, industry associations and other companies. These AM MNEs provide the technology while the research institutions facilitate the involvement of local experts, skilled workers, access to industries and site-testing. Most of the R&D activities focus on developing AM machinery and platforms for industrial applications (i.e. maritime, aerospace, health, manufacturing) or conducting research on new materials and products for AM (e.g. 3D-printed magnets and electromagnetic components, 3D-printed bio-tissues). For example, Thailand's leading petrochemical company, PTT Chemical Group, signed a research collaboration agreement in 2017 with Singapore's Nanyang Technological University (NTU Singapore) to develop materials for 3D printing of automotive parts.[32] In 2020, Structo (Singapore), a provider of dental 3D-printing solutions, entered into a partnership with pro3dure (Germany) for access to pro3dure's range of dental 3D-printing materials.[33] Renishaw (United Kingdom) partners with Singapore Polytechnic on AM skills development and collaborates with 3D Metalforge (Singapore–United States) to fulfil specific requirements to support 3D Metalforge's clients.

(d) Joint ventures

Some AM MNEs have established joint ventures with their ASEAN-based clients to gain access to markets and networks. SIA Engineering (Singapore) established a joint venture (Additive Flight Solutions) with Stratasys (United States) to gain access to additive-manufactured aerospace parts and provide solutions to more than 80 international airlines and aerospace equipment manufacturers. SIA Engineering has extensive operations in the Asia-Pacific region, including some ASEAN Member States (Indonesia, the Philippines, Singapore, Viet Nam), as well as China and Hong Kong (China). Materialise (Belgium), the developer of the Mimics Innovation Suite software that creates image-based, 3D-printed models of medical devices, partnered with Harn Engineering (Thailand) to be its distributor in Thailand. A large consortium – DNV-GL (Norway), Kawasaki Heavy Industry (Japan), Hamworthy Pumps (Norway), Wartsila (Finland), Thyssenkrupp (Germany), Tytus3D (United States), Wilhelmsen Ship Management (Norway), OSM Maritime Group (Norway), Executive Ship Management (Singapore), Thome Ship Management (Singapore), Berge Bulk (Singapore), Carnival Maritime (Germany) and Ivaldi Group (United States) – was formed in December 2020 under a Joint Industry Programme supported by the Singapore Shipping Association and the National Additive Manufacturing Innovation Cluster. The consortium cooperates on developing innovative AM technologies for the development of 10 kinds of marine parts including valve components, engine components and fuel nozzles for various vessel types, such as car carriers, offshore vessels, bulk carriers and chemical tankers.[34]

Table 3.29. Partnerships and collaborations of AM MNEs in ASEAN (Selected cases)

MNE (nationality)	Year	Partner in ASEAN Member State	Location in ASEAN	Partner	Activity
Autodesk (United States)	2019	Science and Technology Ministry/National Science and Technology Development Agency	Thailand	Government agencies	Establish a joint digital manufacturing platform in support of the host country's National Digital Economy Master Plan
	2016	MIMOS (Malaysia's national applied research and development centre)	Malaysia	R&D centre	Establish 3D printing facilities in Malaysia
Emerson (United States)	2016	Nanyang Technological University	Singapore	Academic institution	Train NTU postgraduate students in AM and product development research at Emerson R&D centre
Evonik Industries (Germany)	2019	Nanyang Technological University	Singapore	Academic institution	Develop novel AM technologies for industrial application
GE Additive (United States)	2019	Bralco Advanced Materials (Singapore)	Singapore	Private sector	Develop metal AM technology for applications in the aerospace, medical, automotive, energy, industrial automation and robotics industries
GKN Aerospace (United Kingdom)	2018	Malaysian Investment Development Authority	Malaysia	Government agency	Establish an Asia-Pacific repair and research facility for customers that focuses on the application of AM technology in repair of engine parts
HP (United States)	2018	Nanyang Technological University and the Singapore National Research Foundation	Singapore	Research institutions	Establish HP-NTU Corporate Innovation Lab, which focuses on digital manufacturing technologies (e.g. 3D printing, artificial intelligence, machine learning)
Materialise (Belgium)	2016	Malaysian Industrial Development Authority	Malaysia	Government agency	Establish a 3D printing centre of excellence
	2015	Structo (Singapore)	Singapore	Private sector	Integrate AM software from Materialise into Structo hardware to offer a turnkey solution for ultra-rapid prototyping
Reinshaw (United Kingdom)	2018	Singapore Polytechnic	Singapore	Academic institution	Build skilled AM manpower resources through training and nurturing talents
	2016	3D Metalforge	Singapore-United States	Private sector	Supply AM machines to 3D Metalforge and collaborate to address specific requirements of 3D Metalforge's clients
Siemens (Germany) Advance Manufacturing Transformation Center	2019	National Additive Manufacturing Innovation Cluster	Singapore	Government agency	Offer industry transition programme to bridge the gap between R&D and implementation or AM technology
SLM Solutions (Germany)	2014	Nanyang Technical University	Singapore	Academic institution	Establish the NTU Additive Manufacturing Centre
Stratasys (United States)	2016	University of Malaysia Centre for Biomedical and Technology Integration	Malaysia	Research institution	Develop 3D printing training simulators for neurosurgery

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Table 3.29. Partnerships and collaborations of AM MNEs in ASEAN (Selected cases) (Concluded)

MNE (nationality)	Year	Partner in ASEAN Member State	Location in ASEAN	Partner	Activity
Sodick (Japan)	2019	Jurong Corporation, Economic Development Board	Singapore	Government agency	Establish a technology centre to collaborate with other companies in developing, testing and adopting new AM ideas and concepts, and to hold seminars and training courses on AM solutions
Thyssenkrupp (Germany)	2019	Economic Development Board	Singapore	Government agency	Facilitate the work of the Additive Manufacturing TechCenter Hub on AM solutions for customers in the marine and offshore, automotive, cement, chemical, mining and other heavy industries
Thyssenkrupp (Germany) Additive Manufacturing TechCenter Hub	2019	Wilhelmsen (Norway)	Singapore	Private sector	Jointly develop AM for the maritime industry
TÜV SÜD (Germany)	2019	National University of Singapore: Centre for Additive Manufacturing	Singapore	Research institution	Introduce 3D-printed implants for people
Yamazaki Mazak (Japan)	2017	Machining Cloud (United States)	Singapore	Private sector	Build on cloud technology for application of AM technology

Sources: Company and government agency websites and media.

3.5.2. Drivers and motivations

AM MNEs invest in ASEAN to access to a large regional market and increasing demand for industrial AM equipment and solutions (table 3.30). GKN Aerospace (United Kingdom) expanded its footprint in ASEAN because of market factors, by establishing an engine and repair facility in Malaysia in 2018 with a special focus on R&D in 3D printing and application of the technology. Hewlett Packard (United States) sees ASEAN as an important 3D printing market, given the region's vibrant manufacturing industry and expectations that 3D printing usage in the region will grow rapidly. It also established a research facility with the NTU in 2019 to focus on digital manufacturing technologies and industrial 3D printing applications.[35] Underwriters Laboratories (United States) established its Global Additive Manufacturing Center of Excellence and its international headquarters in Singapore, influenced by increasing market demand for AM in the region. Ultra Clean (United States) established a presence in ASEAN because many of its clients are already present in the region and others have indicated plans to be in ASEAN in the future. The availability of skilled engineering talent and a strong base of suppliers in precision engineering encouraged the company to set up a regional centre in Singapore to serve the region's AM market. Thyssenkrupp (Germany) has an extensive presence in ASEAN because of the region's AM market potential and the supporting facilities available in Member States.

Table 3.30. Motivations of FDI in AM in ASEAN

Company	Headquarters	Reasons
3D Metalforge	Singapore–United States	3D Metalforge opened a $1.8 million end-to-end metal 3D printing facility in Singapore in 2017 because of its strategic location, conducive technology ecosystem and policy support for the development of AM industry.
DNV GL	Norway	Rising interest in AM in Asia-Pacific was a key factor for establishing the Global Additive Manufacturing Centre of Excellence in Singapore.
EOS	Germany	Regional market opportunities for 3D printing: Customers in Asia Pacific are demanding assistance with Industry 4.0 technologies.
Evonik	Germany	Southeast Asia's growing demand for advanced manufacturing technology solutions influenced the company to establish a R&D hub in Singapore.
Farsoon Technologies	China	Market potential and government support in Thailand played an important role. Partnership with a local Thai company (Micap) provides an opportunity to supply AM systems to customers.
Formlabs	United States	Market expansion and increased demand were key factors for adding distribution channels and customer support in Singapore and the region.
GKN Aerospace	United Kingdom	Government support facilitated the setting up of a 3D printing repair facility in Malaysia is to support customers in the region.
Hewlett Packard	United States	Rapid growth in 3D printing usage and the market potential in ASEAN are major drivers. Operating close to customers is important in supplying AM technology solutions and equipment, including providing training and other services. The existence of strategic partners such as quality research institutions played an influencing role.
Materialise	Belgium	Proximity to partners and customers in the region, as well as its existing facilities (in engineering and software development) in Malaysia, were factors.
Optomec	United States	Growing demand for its AM solutions in the Asia-Pacific market led to establishment of a regional headquarters in Singapore, to strengthen its presence in the region.
Siemens Digital Industries ASEAN	Germany	The anchoring of major players at Singapore's Jurong Innovation District (JID) was a key reason for the choice to locate Siemens Digital Industries ASEAN there.
SLM Solutions	Germany	Growing market opportunities for 3D printing is a key factor for the company's expansion in ASEAN. The new office in Singapore offers proximity to customers in the region, and a joint laboratory agreement with Nanyang Technological University supports SLM's research work.
Sodick	Japan	Growing use of AM technologies in ASEAN is a main reason for the company to be more engaged in the region. It opened its Techno Centre in Singapore to support clients in ASEAN in adopting advanced manufacturing technologies.
Thyssenkrupp	Germany	Market factors, rapid manufacturing growth and promising prospects for 3D printing in ASEAN are key factors for the company's expansion in the region. It launched the Additive Manufacturing TechCenter Hub in Singapore as a regional hub to serve clients in ASEAN.
Ultimaker	Netherlands	The growing demand for 3D printing technologies in the region influenced the company to open offices in Singapore.
UPS	United States	The need to stay relevant in the increasingly competitive and growing use of 3D printing in the logistics industry in the region was a key reason for the company to establish an on-demand manufacturing facility and centre of excellence in Singapore.
Voestalpine	Austria	The opportunity to gain access to the growing regional AM market led the company to establish the Voestalpine Additive Manufacturing Center Singapore.
New Kinpo Group	Taiwan Province of China	Host-country and regional market opportunities, including the existence of a local partner, were important factors.
Yamazaki Mazak	Japan	Southeast Asia's growing market for 3D printing and demand for advanced manufacturing technologies was a factor. The centre is also its ASEAN headquarters.

Sources: Company and government websites, and media.

3.5.3. AM ecosystem in ASEAN

The presence of an efficient AM ecosystem or cluster is a key determinant for attracting FDI in AM activities. Some ASEAN Member States provide institutional support and investment incentives, and are developing industrial facilities to attract advanced manufacturing activities, including in AM (box 3.10). In some cases, they partner with the private sector (local companies and MNEs) in developing an advanced manufacturing ecosystem.

Box 3.10. Institutional support for AM development (Selected cases)

Some ASEAN Member States provide dedicated industrial facilities and institutional support for the development of the high-tech and advanced manufacturing industry, including AM. For instance, *Malaysia* provides high-tech or industrial parks to attract high value added investment in high-tech research, development and advanced manufacturing activities. These dedicated industrial facilities include Kulim Hi-Tech Park (Kulim, Kedah), Technology Park Malaysia (Bukit Jalil, Kuala Lumpur) and Nusajaya Tech Park (Iskandar Puteri, Johor). In addition, the MIDA provides investment incentives for high-tech, R&D, and Industry 4.0-related activities including AM. Iskandar Malaysia offers investors various types of investment facilitation support, advanced industrial parks and an improving high-tech ecosystem for advanced manufacturing technologies (including AM). It has five flagship zones that are geographically targeted economic development areas for promoted economic clusters. Each zone is a cluster of its own (e.g. Flagship Zone D, Pasir Gudang-Tanjung Lasat, promotes electrical and electronics, transportation, distribution and logistics, petrochemical and food and agro-processing clusters).[a] Nusajaya Tech Park is in Iskandar Malaysia's flagship zone B and is designed for key growth industries such as aerospace, precision engineering, electronics and ICT. GKN Aerospace (United Kingdom) established its aerospace-engine research and repair facility focused on 3D printing in this technology park as well.

Singapore has invested more than $200 million in AM-related research.[b] The Government continues to strengthen the country's technological ecosystem to attract investments in Industry 4.0 activities, including in 3D printing. Investment incentives and institutional support are provided to facilitate investment in AM. Specific institutions for AM have been established, which include the National Additive Manufacturing Innovation Cluster and the Singapore Centre of 3D Printing based in the NTU, which in turn partnered with many MNEs to advance R&D in AM. Specialized industrial parks have been established to provide industrial space to attract MNEs in advanced manufacturing technology, including in AM. Such specialized industrial parks are typically situated near tertiary institutions, major seaports or airports. One such facility is the Jurong Innovation District (JID), which offers dedicated industrial facilities to attract advanced manufacturing and innovative technologies through a cluster strategy. The cluster includes key institutions such as the Singapore Agency for Science, Technology and Research, and the NTU. The JID provides an environment where companies can collaborate, conduct research, design and develop innovative ideas in one integrated district, where advanced industrial facilities are easily accessible. It also supports transformation to Industry 4.0 with initiatives such as an industrial AM facility, 5G technology for Industry 4.0 and development of skills and talents for advanced manufacturing technologies.

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Box 3.10. Institutional support for AM development (Selected cases) (Concluded)

Other dedicated industrial parks include Seletar Aerospace Park and Medtech Park, which is near the NTU. Companies benefit from colocating near similar business clusters to collaborate on new solutions and incubation of new technologies.[c] Attracted by the cluster development and the improving Industry 4.0 ecosystem, many industrial MNEs (e.g. ABB (Switzerland) and Siemens (Germany)) have established their advanced manufacturing centres of excellence in Singapore.[d] Sodick (Japan) established a Techno Centre in the JID to showcase the latest additive manufacturing technologies and drive greater adoption of advanced manufacturing technologies in Singapore.

In Thailand, the automotive industry is leading the potential market for AM application, as global automakers (e.g. Toyota (Japan) and BMW (Germany)) adopt AM technology for the production of certain type of parts and components. The MNEs are buying 3D printers from local companies such as Septillion (which sold Formlab printers to Toyota) for internal R&D, prototyping and tooling applications.[e] Kasetsart University launched the Digital Prototyping Laboratory to run university education programmes and research development. Septillion assisted in setting up the printer lab using 3D printing machines from Ultimaker (Netherland). The Science and Technology Ministry signed a memorandum of understanding with Autodesk (United States) and the National Science and Technology Development Agency to establish a joint digital manufacturing platform to support the National Digital Economy Master Plan. The aim is to improve manufacturing competitiveness through industry-wide adoption of leading-edge 3D technologies and digital manufacturing capabilities.[f] The Thai Board of Investment (BOI) is promoting investment in Industry 4.0 technologies, including 3D printing. It provides investment incentives and investment facilitation measures (e.g. information and advisory services) to both local and foreign AM companies.

Sources: MIDA, Singapore EDB, Thai BOI, JID, Iskandar Malaysia and media.
[a] Iskandar Malaysia (https://iskandarmalaysia.com.my/SCIM/download/imsc_booklet.pdf).
[b] Thyssenkrupp (2019).
[c] *Business Times*, "Shaping business parks, mixed-use clusters for Industry 4.0", 28 September 2017.
[d] Economic Development Board, "Partnering companies for success" (https://www.edb.gov.sg/en/our-industries/advanced-manufacturing.html).
[e] *The Nation*, "Thailand a rising star in Asean's additive manufacturing scene", 13 August 2019.
[f] *3D Printing Media*, "Septillion goes from neighborhood shop to major 3D printer distributor in Thailand", 14 March 2018 (https://www.3dprintingmedia.network/septillion-goes-neighborhood-shop-major-3d-printer-distributor-thailand).

Governments in the region are encouraging firms to adopt AM and other Industry 4.0 technologies to improve manufacturing efficiency. The application of AM can also accelerate the growth and efficiency of the region's other industries (e.g. aerospace, medical devices and maritime). The ability of AM to print complicated angled parts and components with a variety of materials is an important driver. MNEs and local companies in ASEAN are adopting AM for reasons such as lowering costs, reducing inventory, accelerating time-to-market, customizing and producing higher-quality or more precise parts and equipment (box 3.11). These reasons are encouraging MNEs and local companies to use AM, which in turn makes the region attractive for FDI in AM-related activities (demand pull factors). The different stakeholders together, including through public-private partnership will help bring about an efficient AM ecosystem.

Box 3.11. Impact of AM technologies in ASEAN (Selected cases)

The benefits of AM technologies are not confined to manufacturing. Other industries in the region are also increasingly deploying AM. Examples below highlight some specific benefits of AM in different industries.

Manufacturing

The HP (United States) team in Singapore converts traditionally manufactured parts into 3D printable parts. One example is a drill extraction shoe used in the manufacture of HP printhead nozzles to make laser drilling processes more efficient. The weight saving is 90 per cent in total but the real value is in the production cost of the part. The traditional part costs $450, whereas the 3D printed part costs $18. The parts for HP machines are 3D printed en masse at a 3D printing facility for contract manufacturing owned by Jabil (United States), based in Singapore.[a]

Aerospace

SIA Engineering (Singapore) established a joint venture with Stratasys (United States) to set up an AM service center in Singapore to accelerate production of 3D-printed aviation parts. Stratasys has knowledge and experience in additive manufacturing, and SIA Engineering has experience with maintenance, repair and overhaul service for aerospace clients. The partnership helps clients with scheduled maintenance and on-demand parts solutions, where application of AM technology can improve efficiency.

Health care

In 2018, Materialise (Belgium) introduced 3D medical software called the "Mimics Innovation Suite" to the Thai market. The software creates image-based 3D-printed models, design medical devices that fit each patient's unique anatomy, and plan procedures preoperatively to help surgeons make better-informed decisions. The software enables medical experts to use 3D planning software to design a patient-specific treatment approach instead of adapting a patient's problem to the possible solutions. In Singapore, KK Women's and Children's Hospital in Singapore is using 3D-printed heart models to train surgeons on complex procedures. In Malaysia, Materialise and orthopaedic surgeons from Pantai Hospital Kuala Lumpur worked together in reconstructing a patient's bones for mobility, using virtual surgical planning and 3D-printed surgical guides.

Maritime

In 2019, Wilhelmsen and Ivaldi (both Norway) launched in Singapore a programme to supply 3D-printed spare parts on demand to ships and other vessels. The programme involved maritime companies such as Carnival Maritime (Germany), Thome Ship Management (Singapore), OSM Maritime Group (Norway), Berge Bulk (Singapore) and Executive Ship Management (Singapore). Wilhelmsen and Ivaldi have supplied 3D-printed parts and scupper plugs to Berge Bulk vessel in Singapore.[b] 3D Metalforge (Singapore–United States) designed and produced an impeller through 3D printing technology in less than three weeks for a Singapore-based client that runs a small fleet of highly specialized ships. Designing and producing an impeller takes 6–10 weeks through traditional manufacturing processes.

Sources: Company and government websites, and media.

[a] *TCT Magazine*, "Onwards Singapore: Diving into the prosperous Southeast-Asia city-state's additive manufacturing expedition", 25 July 2019.

[b] Scupper plugs are expensive and there are no universal dimensions, which means that when an element breaks, a new scupper plug is needed. With additive manufacturing, the company can procure scupper plugs faster, cheaper and locally (Source: 3D Printing Industry, "6 Strategic maritime customers benefit from Wilhemsen and Ivaldi 3D printing on demand", 2 December 2019 (https://3dprintingindustry.com/news/6-strategic-maritime-customers-benefit-from-wilhelmsen-and-ivaldi-3d-printing-on-demand-165772/)).

3.6. DIGITALIZATION OF MANUFACTURING

Automation lays the foundation for applications of more advanced industrial technologies such as the IIoT, and 5G infrastructure provides the backbone for seamless and faster connectivity and communication, as well as the enabling of huge data requirements. The application of the IIoT leads to a state of smart manufacturing and Industry 4.0. Integration of automation, connectivity, data and advanced digital technologies and "machine communicating with machine" (e.g. the IIoT) are key components for attaining the digitalization of manufacturing and smart factories.

A manufacturing company employing these technologies and connecting them can unlock potential to generate new insights and facilitate real-time decision-making. Industry 4.0 technologies can be applied not just in factories but across a broader business setting, connecting production and other business functions within a company to achieve greater efficiency and productivity. When more manufacturing companies adopt advanced manufacturing technologies, the industry becomes more competitive, more efficient, ready for Industry 4.0 and conducive to FDI.

Manufacturers in ASEAN are increasingly adopting IIoT technologies to further automate, enable a greater interconnection between machine and production process, and perform data analytics. Some MNEs and local companies in the region have also established smart factories that integrate different aspects of Industry 4.0 technologies to achieve intelligent manufacturing beyond the traditional production automation systems. They enhance the advanced manufacturing ecosystem or Industry 4.0 environment.

3.6.1. Industrial internet of things

MNEs are playing an important role in investing and providing IIoT or Industry 4.0 technologies to factories in the region. They also develop or install smart factories for clients in ASEAN. Factories owned by MNEs are adopting Industry 4.0 technologies (e.g. automotive and electronics industries). Many MNEs have also established centres of excellence and R&D facilities to develop and customize technology solutions for local and MNE clients. The adoption of Industry 4.0 technologies and the establishment of smart factories by MNEs has produced a demonstration effect that encourages local firms to transform to Industry 4.0. For example, Dexa Group, an Indonesian pharmaceutical company, deployed the Alibaba Cloud IoT solution to scale up its operation to meet demand, control costs and maintain data security. Shera, a Thai manufacturer and distributor of fiber cement products, adopted Microsoft digital solutions and platforms, including the IoT, across its business structure to increase productivity. Tan Boon Ming, a one-stop appliance store in Malaysia, deployed Microsoft digital and IoT solutions for data synchronization and integration with its existing warehouse management system. The solutions enabled the company to obtain remotely real-time data on the company's warehouse, logistics, inventory and sales situation.

Demand for IoT technologies in ASEAN is rising, from the digitalization of manufacturing activities to the upgrading of production facilities and the growth of the digital economy (e-commerce and online activities). Indonesia, Malaysia, the Philippines, Singapore, Thailand

and Viet Nam are major markets in the region for IoT spending (table 3.31). This stems from their strong focus on smart cities development, manufacturing and the rapidly growing digital economy. IoT spending in the region is expected to grow rapidly over the next few years.

The prospects for the IIoT in ASEAN are promising, as more manufacturers are thinking of adopting advanced manufacturing technologies. Most respondents to the 2019 Asia IoT Business Platform survey of more than 650 enterprises in the manufacturing and industrial sector from Indonesia, Thailand, Malaysia, the Philippines and Viet Nam affirmed that they are looking to digital technology to achieve cost savings. Some 76 per cent plan to adopt digital technology to improve business processes.[36]

Table 3.31. IoT market potential in selected ASEAN Member States

Country	Size (2018–2020)	Projected
Indonesia	$23 billion (2018)	$111 billion (2025)[a, b]
Malaysia	$2 billion (2020)	$10 billion (2025)[a]
Philippines	$767 million (2020 projected)	..
Singapore	$18 billion (2018)[c]	..
Thailand	$120 million (2018)	$2 billion (2030)
Viet Nam	$1 billion (2018)	$3 billion (2024)[d]

Sources: Industry reports and media.
[a] The exchange rate used for projections is based on 2020 year average from the International Monetary Fund's International Financial Statistics.
[b] OpenGovAsia, "The Potential of IoT in Indonesia", 17 November 2018.
[c] Infocomm Media Development Authority (Singapore), "Technology and R&D Roadmaps: Internet of Things", October 2015.
[d] TechSci Research, "Vietnam IoT in manufacturing, forecast & opportunities, 2026", March 2021.

(a) Roles of MNEs in IIoT

As with IA (section 3.4), ASEAN is seen as an important market with growing opportunities for sale and adoption of advanced manufacturing digital technologies such as the IIoT to support Industry 4.0 transformation. More MNEs related to IIoT solutions are setting up operation in the region because of market factors and to be close to clients. Major MNEs such as Bosch (Germany), GE (United States), Mitsubishi Electric (Japan), Oracle (United States) and Schneider Electric (France), have established a strong foothold in the region to offer IIoT solutions.

MNEs associated with IIoT technologies operate in ASEAN through a number of modalities, such as (i) supplying digital technology solutions for clients through a physical presence, (ii) building or upgrading factories with IIoT solutions, (iii) establishing R&D centres to develop or customize digital technology solutions to meet specific local demand and (iv) establishing centres of excellence to showcase and promote the possibility of Industry 4.0 technologies (such as the IIoT).

(b) Top 50 global MNEs in IIoT

Of the top 50 IIoT MNEs, 44 have a physical presence in ASEAN and 6 are connected indirectly through representatives and their partners (annex table 3.3); 15 of them are also in the top 50 IA MNEs (section 3.4). This suggests that these 15 companies operate on an end-to-end basis, from low-to medium-technology automation to complex advanced manufacturing digitalization solutions. The six IIoT MNEs that do not have a physical presence operate through foreign technology partners that have extensive activities in ASEAN. These partners provide connection to their cloud platforms and networks. For example, Juniper Networks (United States) partnered with IBM (United States) and NEC and NTT (both Japan) for connection to their respective global cloud ecosystems and through their presence in six major ASEAN markets (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam). Vodafone (United Kingdom), which does not have a physical presence in ASEAN, has partnership arrangements with network operators in Singapore.

The top IIoT MNEs are each present in more than four ASEAN countries, on average – most commonly in Singapore, Malaysia, Indonesia, Thailand and Viet Nam, in that order. In some cases, they also have operations in the Philippines and other ASEAN Member States (e.g. ABB (Switzerland), Infineon Technologies (United States) and Samsung Electronics (Republic of Korea)). These MNEs operate in multiple ASEAN countries with multiple business functions, from sales and distribution subsidiaries to manufacturing, R&D and specialized technology centres.

Indonesia has the greatest number of sales and distribution offices because of its geographical size and archipelagic structure. With the exception of Malaysia, the other industrialized ASEAN Member States host about the same numbers of sales and distribution offices – though given its size, Singapore hosts proportionately more. This concentration is caused by the presence of a large pool of manufacturing and services MNEs in Singapore. In addition, some of the top IIoT MNEs have established additional sales and distribution offices in that country to supply IIoT products and technology solutions, and some additional offices to oversee regional sales and distribution activities from Singapore. Broadcom (United States) established an office in Singapore to coordinate sales in the region. Analog Devices (United States) has an office in Singapore to handle sales in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Phoenix Contact (Germany) and STMicroelectronics (Switzerland) have regional headquarters in Singapore. The rest of the ASEAN Member States host fewer sales and distribution offices because of their relatively smaller market size and because their markets are also overseen by subsidiaries or offices based in Singapore or Thailand. For example, Hitachi has offices in Thailand that oversee sales and distribution in Cambodia and in the Lao People's Democratic Republic.

Business functions

In terms of business functions, the top IIoT MNEs have sales and distribution operations in nine ASEAN Member States and manufacturing activities that also produce IIoT products in six of them. Although sales and distribution is the largest business function of the top IIoT MNEs, most also have other significant business operations such as manufacturing, R&D and specialized centres, including centres of excellence.

Many of the specialized centres are in five ASEAN countries – Singapore, Malaysia, Indonesia, Viet Nam and Thailand, in that order. These specialized centres cover activities in technology development and innovation, IIoT experience and showcase facilities, and promotion of IIoT solutions. For example, Dell Technologies (United States) launched a $23 million Global Innovation Hub in Singapore in February 2021. The hub supports and promotes adoption of digital solutions by customers in Singapore and in the region. It also houses R&D facilities for design and development of key products such as monitors and client peripherals, a hardware prototyping laboratory dedicated to product design and innovation, and an AI experience centre. Schneider Electric (France) has deployed a wide range of IIoT technologies and introduced virtual and augmented reality to its Batam smart factory in Indonesia, which also serves as a showcase centre for IIoT applications in manufacturing. Hitachi (Japan) has opened an IIoT centre (Lumada Centre Southeast Asia) in Thailand as a test bed for IoT technology.

A number of these specialized centres are also digital hubs and cloud collaboration hubs functioning as collaborative facilities to further develop and implement cloud-based solutions. Nokia (Finland) launched a cloud collaboration hub in Singapore in 2018 as an execution centre to provide multi-vendor cloud services encompassing strategy, design and execution. Accenture (Ireland) opened a digital hub in Singapore in 2017 to help clients in the region co-create and adopt advanced digital solutions.

Regional headquarters and centres of excellence

Of the top IIoT MNEs, 30 have established regional headquarters to coordinate operations in ASEAN (table 3.32), which in most cases act as regional distribution hubs, and to develop technology solutions customized to the needs of industries in the region. Most regional operations include R&D activities. Thirteen MNEs have set up specialized centres, including centres of excellence. The purpose of these centres is to explore, create, develop and fine-tune new or hybrid/specialized technology solutions that meet clients' needs. They also showcase to clients the experience and benefits of using advanced industrial manufacturing technologies.

MNEs establish centres of excellence for various reasons. Most of these centres are based in Singapore (e.g. Microsoft's Experience Centre Asia and Siemen's Advanced Manufacturing Transformation Centre) because of the availability of a more advanced IT infrastructure system and supportive ecosystem (annex table 3.4).[37] Some centres have been established in Indonesia, Malaysia, Thailand and Viet Nam to be near current and potential customers.

Samsung Electronics (Republic of Korea) established its biggest R&D centre for development and adaptation of industrial technologies in Viet Nam because it already has a significant manufacturing and value chain presence in that host country. Most of Viet Nam's exports of smartphones and spare parts are produced by Samsung Electronics. *Omron* (Japan) established automation centres in Thailand in 2015 and Indonesia in 2016, drawn by the rapidly growing regional automotive production involving these countries.

Table 3.32. Regional headquarters and centres of excellence of top 50 IIoT MNEs (Selected cases)

Company	Nationality	Regional headquarters	Location	Centre of excellence	Location
ABB	Switzerland	Southeast Asia	Singapore	Customer Innovation Centre offering digitalization services including IIoT Robotics Digital Operations Centre Robotics & Automation Solution Centre	Singapore Malaysia Viet Nam
Amazon Web Services	United States	Asia	Singapore	..	..
AT&T	United States	Southeast Asia	Singapore	..	..
Bosch	Germany	Southeast Asia	Singapore	R&D centres focusing on software and engineering and on computer-aided design, simulation and testing of automotive technologies such as continuously variable transmission and fuel injection Bosch Regional Centre (for advanced manufacturing technologies and skills training)	Viet Nam Singapore
Cisco Systems	United States	Asia-Pacific	Singapore	..	..
GE	United States	Southeast Asia	Malaysia	Asia Digital Operations Centre	Singapore
Hitachi Industry Solutions	Japan	Southeast Asia	Singapore	Lumada Centre	Thailand
Honeywell International	United States	Southeast Asia	Malaysia	Asian Industrial Cyber Security Centre	Singapore
Microsoft	United States	Asia-Pacific	Singapore	Asia Experience Centre	Singapore
NXP Semiconductors	Netherlands	Southeast Asia and Australia	Singapore	Global Distribution Centre for Asia logistics strategy and programmes	Singapore
Omron	Japan	Asia-Pacific	Singapore	Omron Automation Centres	Indonesia Thailand Singapore
Rockwell Automation	United States	Southeast Asia	Singapore	Connected Services Experience Centre	Singapore
Samsung Electronics	Republic of Korea	..	..	R&D Centre for Industrial Technologies in Southeast Asia	Viet Nam
SAP	Germany	Asia-Pacific	Singapore	..	..
Schneider Electric	Germany	East Asia and Japan	Singapore	Smart factory	Indonesia Philippines
Siemens	Germany	Asia-Pacific	Singapore	Advanced Manufacturing Transformation Centre, which combines three facilities: the Digital Enterprise Experience Centre, the Additive Manufacturing Experience Centre and the Rental Labs	Singapore

Source: ASEAN Investment Report 2020–2021 research, based on annex table 3.4 and company websites.

In 2017, the company built an advanced automation centre in Singapore to explore the use of advanced AI, IIoT and robot technologies for manufacturing applications. The Singapore centre is a working model of Omron's Smart and Future Factory that showcases the application of manufacturing intelligence technologies and solutions.

ABB (Switzerland) established robotics centres in Viet Nam in 2018 and in Malaysia in 2019. The centre in Malaysia focuses on ASEAN-based manufacturers that are in transition to using connected manufacturing technologies.[38] Its robotic technical and service centre in Viet Nam supports clients interested in using advanced digital manufacturing technologies. Viet Nam was chosen because the country is rapidly evolving into an important manufacturing base. *GE, Microsoft* (both United States) and *Siemens* (Germany) have all established centres of excellence in Singapore. *Rockwell Automation* (United States) has a centre in Thailand. The company views the manufacturing industry in Thailand as starting to adopt more automation as more firms are gearing up for digital transformation. The Government is also pushing for Industry 4.0 transformation with investment promotion schemes.

Strategic partnerships and alliances with host governments or research institutions have also played a role in determining the locations of centres. For example, Siemens worked with the Singapore Economic Development Board in establishing a fully integrated digitalization hub to develop IoT and Industry 4.0 innovations in collaboration with customers, partners and universities.[39]

MNE profiles

Most of the top 50 MNEs in ASEAN are from the United States (23) and Europe (14). Their dominance in the IIoT domain explains their competitive advantage, as does the high barrier to entry (particularly in business segments with advanced technology content). Another reason is that many of these MNEs are already operating in the automation segment. They are able to expand the spectrum of their technology solutions to provide clients with end-to-end automation and advanced digital technology solutions (i.e. from low-automation technology to complex digital solutions, including the IIoT). Most are involved with operations that cover both IIoT hardware and technology solutions (table 3.33).

The top IIoT MNEs can be clustered into five categories (table 3.34). Most fall in the industrial technology and automation group, but companies oriented to telecommunication and technology also build on their expertise to serve clients in the IIoT business segment. For example, Nokia (Finland) has established the Impact IoT platform, which provides enterprises and service providers with 5G technology for dedicated industrial use (e.g. wireless connectivity and data transmission). PTC (United States), using its software development and IIoT expertise, helps clients in the region adopt IIoT solutions for Industry 4.0 transformation. Bosch (Germany) combines its automation hardware and digital technology to create more advanced automation platforms. One of its automation platforms unifies machine control systems, IT and IIoT, eliminating the traditional boundaries between them.[40]

Table 3.33. Top 50 MNEs: Type of IIoT business

Number and nationality of MNEs[a]	Type of IIoT solutions provided		
	Both hardware and technology	Hardware[b]	Technology solutions[c]
United States (23)	13	3	7
Europe (14)	9	..	5
Japan (3)	2	1	..
China (1)	1	..	..
India (1)	..	..	1
Republic of Korea (1)	1	..	..
Taiwan Province of China (1)	1	..	..
Others (6)	..	..	..

Source: Annex table 3.3.

[a] The top 50 MNEs are mainly from the United States, Europe and Japan. 6 MNEs do not have a physical presence in ASEAN but are connected through representatives and their technology partners operating in the region.

[b] MNEs that provide IIoT hardware are engaged in the manufacturing of industrial products, which include IIoT hardware such as processors, sensors, chips, automation and control, actuators.

[c] MNEs that provide IIoT technology solutions (software) such as platforms, security and network technologies.

Table 3.34. Categories of the top IIoT MNEs in ASEAN

Business category	Activity	No. of MNEs	Selected examples
Business software	Develop application software for IIoT solutions	3	C3 IoT (United States) PTC (United States) SAP (Germany)
Diversified group of companies	As conglomerates, operate in many manufacturing industries (e.g. automotive, electronics, IA machines and devices) and in many service industries (e.g. financial services, transport, logistics, energy and trading)	3	Mitsubishi (Japan) Hitachi (Japan) GE (United States)
Industrial technology, automation and semiconductors	Manufacture a wide range of products used in IIoT applications, such as processors, microchips, sensors, analogs, automation equipment and robots	29	ABB (Switzerland) Broadcom (United States) Cisco Systems (United States) Infineon Technologies (Germany) Intel (United States) Huawei (China) Micron Technology (United States) Nvidia (United States) Rockwell Automation (United States) Siemens (Germany)
Technology	Leverage digital technologies and ICT infrastructure to develop and provide IIoT software solutions	5	Amazon Web Services (United States) Google (United States) Microsoft (United States) Samsung (Republic of Korea)
Telecommunication	Extend telecommunication technologies and digital expertise into IIoT solutions	4	AT&T (United States) Ericsson (Sweden) Nokia (Finland) Telefonica (Spain)

Source: Based on Annex table 3.3.

Note: 6 do not have a physical presence in ASEAN..

Similarities and differences in top IIoT MNEs

Key similarities among the top IIoT MNEs are a regional presence and a focus on sales and distribution. A majority of them have a presence in multiple countries. Sales and distribution subsidiaries or offices are the dominant business functions and are mostly located in vibrant manufacturing cities (e.g. Jakarta, Penang, Singapore), and in locations that host large clusters of manufacturers (e.g. special economic zones). IIoT-related hardware MNEs manufacture almost the same type of products (e.g. semiconductors, microprocessors, sensors). MNEs from the United States (13), Europe (9) and Japan (2) operate proportionately more often end-to-end on the IIoT business spectrum.

Significant differences relate to business functions, target markets and geographical spread (figures 3.4). The MNEs from the United States tend to focus on sales and distribution activities and regional headquarters functions. They tend to have offices in about four countries,

Figure 3.4. Key differences of major players in advanced manufacturing technology solutions

Key differences	United States Headquartered	Japan Headquartered	European Headquartered
Features and business focus	MNEs specialized expertise in IT-based services (cloud computing service providers, cyber security, data center operators)	Usually part of a large MNE group, with expertise in manufacturing technology solutions for automotive, electronic, semi-conductor and telecommunications	MNEs involved in industrial operations with expertise in manufacturing technology for industrial hardware (e.g. automation, robotic, additive manufacturing solutions)
IIoT solution and target market	IIoT is part of the IT-based/cloud services Clients are United States MNEs and other customers in ASEAN.	IIoT is a requirement in the transformation of the manufacturing operations to Industry 4.0. Major clients include manufacturing subsidiaries of the group, and other Japanese manufacturers in the region.	IIoT solution compliments industrial hardware products offered by European suppliers. Major clients include European and ASEAN companies in the region. Also serve other MNEs.
MNEs	Amazon Web Services, Autodesk*, Cisco, Google Cloud, IBM Cloud, Honeywell, Intel, Microsoft, Oracle*	Fujitsu*, Hitachi, KDDI*, Mitsubishi Electric, Omron, Yaskawa*	ABB, BBS Automation*, Bosch, B&R Industrial Automation*, NXP Semiconductors, Schneider Electric, Siemens

Source: ASEAN Investment Report 2020–2021 research, based on annex table 3.3, company websites and media.
* MNEs not in the top 50 but are significant players.

fewer than the European MNEs, which tend to be more spread out in the region (typically in six ASEAN Member States). Also, the European MNEs more often tend to establish other business functions such as manufacturing, R&D, training facilities and regional headquarters. The Japanese MNEs, albeit small in number, like European MNEs typically have a presence in five countries. Nine of the United States MNEs are technology companies specializing in the development of software solutions and are in internet-based activities such as cloud computing and data centres. More of the European companies are industrial manufacturers; e.g. ABB (Switzerland), Bosch (Germany) and Schneider (France). The three Japanese MNEs (Hitachi, Mitsubishi Electric and Omron) are diversified groups of companies that manufacture IIoT hardware such as automation control devices, drones and sensors. There are also differences in the establishment of manufacturing functions that also produce IIoT products. The 23 United States MNEs have established 25 manufacturing facilities in all; the 14 European MNEs have established 32 and the 3 Japanese MNEs have established 8.

(c) Other major MNEs in IIoT

Other MNEs that are not in the top 50 also have a significant presence in ASEAN with various business functions (sales and distribution office, regional headquarters, technical centres, training and R&D) (table 3.35). European MNEs include industrial manufacturers B&R Industrial Automation and BBS Automation (both German), which also produce IA and IoT hardware, and industrial software developers Dassault Systèmes (France) and Aveva (United Kingdom). These European MNEs focus mainly on industrial solutions (e.g. manufacturing or software development services). Japanese MNEs such as industrial manufacturers: Yamazaki Mazak manufactures IA machines and Yaskawa produces industrial robots and IA devices (e.g. motion controllers, servos, switches). Other Japanese MNEs such as Fujitsu and Yokogawa are involved in manufacturing and information technology solutions. Some of the MNEs from the United States (i.e. Autodesk, Oracle, Salesforce.com) are involved in ICT and software development. Their involvement in IIoT software solutions reflects a natural expansion of their core expertise.

IIoT solution providers from Japan target the large pool of Japanese manufacturing companies based in ASEAN, primarily those operating in the automotive and electronics industries. In Indonesia and Thailand there is a large cluster of Japanese-owned automotive factories, which provides an attractive “pull” factor for advanced industrial digital technology business in that host country. European MNEs offer advanced industrial manufacturing hardware (including robots) as well as software solutions, as they are also involved in manufacturing advanced technology and industrial hardware (e.g. IA and robots) and IIoT equipment (e.g. sensors, processors, controllers).

Table 3.35. Other major MNE providers of IIoT solutions in ASEAN (Selected cases)

Company	Nationality	IIoT-related solutions	Presence in ASEAN
Autodesk	United States	IIoT software solution, including Autodesk Forge	Offices (Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam) Regional headquarters (Singapore)
Aveva	United Kingdom	Industrial software solutions for digital transformation (e.g. IIoT, cloud, AI, virtual reality)	Offices (Indonesia, Malaysia. Singapore) Training (Malaysia, Singapore)
B&R Industrial Automation	Germany	IIoT hardware and software solutions (e.g. I/O systems, robotics, mobile automation, process controls)	Offices (Malaysia, Thailand) Regional headquarters (Singapore)
BBS Automation	Germany	IIoT hardware and IA solutions	Manufacturing facility and office (Malaysia)
Dassault Systems	France	3D design and engineering software, 3D modeling software to create virtual twins	Office (Thailand)
Fujitsu	Japan	IIoT hardware and software solutions	Office (Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam) Service centre (Indonesia) Regional headquarters (Malaysia, Singapore) Manufacturing (Malaysia, the Philippines, Singapore, Viet Nam) Global delivery centre (Malaysia)
KDDI	Japan	IIoT software solutions, including cloud	Offices (Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Viet Nam)
Oracle	United States	IIoT software solutions, including Oracle's IoT Intelligent Applications Cloud	Offices (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democatic Republic, Malaysia, the Philippines, Singapore, Thailand, Viet Nam)
Salesforce.com	United States	IIoT software solutions including customer resource management platforms (integration services, analytics, IIoT, security, metadata architecture)	Regional headquarters (Singapore)
Yamazaki Mazak	Japan	IIoT hardware solutions, including CNC controls and automation	Smart factory (Singapore) Technical centres (Indonesia, Malaysia, Viet Nam) Technology centre (Thailand)
Yaskawa	Japan	IIoT hardware and industrial robots	Offices (Indonesia, Malaysia, Singapore, Thailand, Viet Nam) Regional headquarters (Singapore)
Yokogawa	Japan	IA and test and measurement solutions, including IIoT solutions	Offices (Indonesia, Malaysia, the Philippines, Singapore Thailand, Viet Nam) Regional headquarters (Singapore)

Source: ASEAN Investment Report 2020–2021 research, based on industry reports and company websites.

(d) Key drivers

Market factors are the primary drivers of major IIoT MNEs in ASEAN (table 3.36). Some MNEs have upgraded their manufacturing facilities in the region (e.g. introducing advanced IA and IIoT technologies) and at the same time customized their advanced manufacturing technology solutions to meet clients' demands. In some cases, their advanced factories are also used to showcase to potential customers the Industry 4.0 experience. For example, NXP Semiconductors (Netherlands) in 2013 increased its investment in R&D by $15 million on top of the $31 million spent in the preceding five years and a $96 million capital expenditure to upgrade its manufacturing facility with new technology capabilities at a joint venture project with Taiwan Semiconductor Manufacturing Company in Singapore.[41]

Table 3.36. Reasons for Industry 4.0 technology suppliers locating in ASEAN

Company	Headquarters	Reasons
Advantech	Taiwan Province of China	Sees ASEAN as a growing market for industrial devices and connectivity. Offers IIoT solutions to clients in the region.
Bosch	Germany	Sees ASEAN as a growing market. Opened its first smart factory in Thailand in 2017 and is focusing on Viet Nam as its key IIoT solutions hub. Established a software and engineering R&D centre in Viet Nam.
Cisco	United States	Sees ASEAN as ready for digitalization transformation. Positioned to help clients in ASEAN make use of big data, IIoT and smart connectivity.
GE	United States	Market opportunity. Sees IIoT business as a multibillion-dollar opportunity for the industry.
Honeywell International	United States	Sees growth opportunities for IIoT and Industry 4.0 solutions as the region's economies continuously develop.
Mitsubishi Electric	Japan	Sees ASEAN as a fast-growing and important market, and a physical presence as important to respond to market and client demands.
Rockwell Automation	United States	ASEAN continues to be a key area of strategic growth for the company. It launched a connected services experience centre in Singapore in 2019 to support clients based in the region in their industrial digitalization transformation.
SAP	Germany	Sees businesses and production operations in ASEAN adjusting to the impact of the COVID-19 pandemic. Plans to take advantage of growth opportunities expected from industrial digitalization.
Schneider Electric	France	Sees ASEAN as a rapidly growing region with significant opportunities for Industry 4.0 application. Established smart factories involving IIoT in Indonesia and the Philippines.
Siemens	Germany	Sees a growing need for advanced technologies in the region. Opened an advanced manufacturing transformation centre in Singapore in September 2020 to support companies in the region in the transition to Industry 4.0.
Yamazaki Mazak	Japan	Sees market opportunities for manufacturing technology solution providers. Strengthened its presence in the region with a smart factory in Singapore and established technical centres in Indonesia, Malaysia and Viet Nam, and a technology centre in Thailand.
Yokogawa	Japan	Sees a growing demand for IT-based solutions from industrial customers in ASEAN to optimize operation efficiency.

Sources: Company websites, industry reports and media.

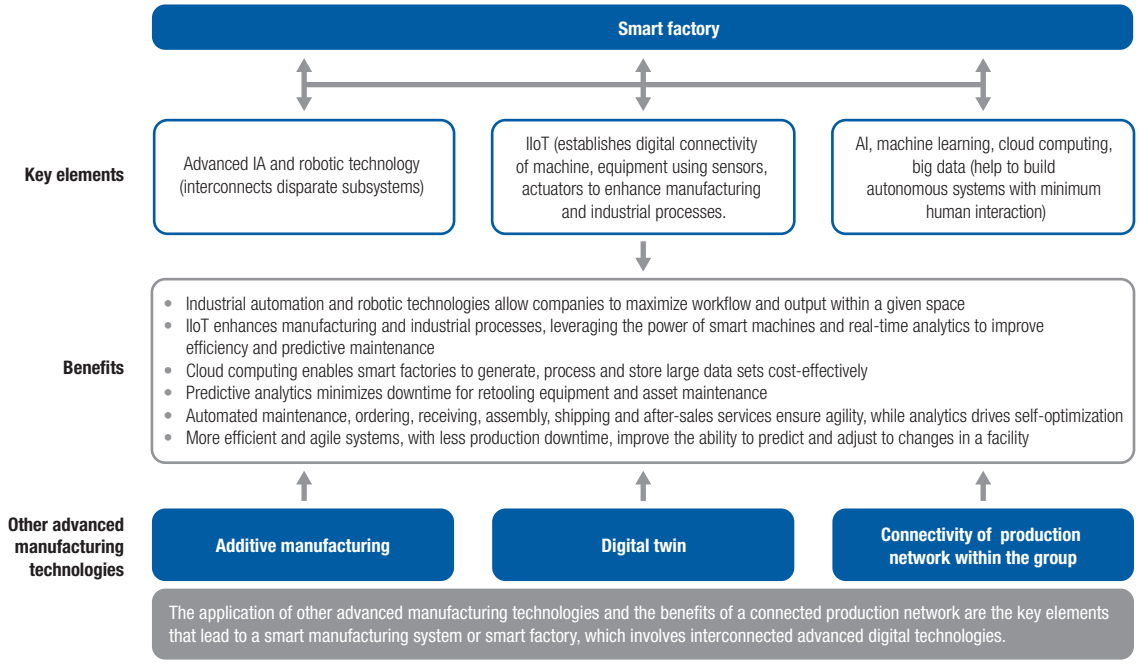
3.6.2. Smart factories in ASEAN

Industry 4.0 technologies are increasingly being applied to factories in ASEAN for product development, production processes and connected manufacturing systems. Important evidence is the development of smart factories (box 3.12), primarily those owned by MNEs, and the increasing use of intelligent manufacturing solutions (e.g. the IIoT) supplied by MNEs in the region. The number of local firms establishing smart factories, albeit small in number, is growing. They have contracted MNEs to supply equipment, technology solutions, installations and build smart factories. Such production facilities involve interconnection and interoperability of advanced digital technologies (e.g. IA, AI-enabled robotic, sensors, machine learning, IIoTs and cloud). However, the use of smart factories in the region is unevenly distributed, with a strong bias towards countries that provide more efficient digital ecosystems and that are major manufacturing hubs.

Box 3.12. Why smart factories?

A smart factory is an advancement from a simple traditional IA system to a cyberphysical environment. It involves the application of advanced digital or Industry 4.0 technologies to achieve optimal autonomous production processes and supply chains of materials and delivery of goods. Smart factory systems integrate a network of machines, computers and digital technologies, which communicate, interconnect and interoperate, collecting and analysing data to enable real-time decisions to improve production (box figure 3.12.1).

Box figure 3.12.1. Key elements of smart factories



Source: *ASEAN Investment Report 2020–2021* research, based on annex tables 3.5 and 3.6, industry reports and media.

(a) MNEs in development of smart factories

Three key categories of actors are major contributors to the development of smart factories in ASEAN (figure 3.5): (i) users, (ii) technology and solution providers, and (iii) R&D institutions and centres of excellence.

Users include foreign and local firms transforming or upgrading manufacturing plants with advanced digital technologies that include the IIoT, data analytics, real-time monitoring of processes and preventive maintenance. Suppliers are primarily foreign providers of technology and advanced digital manufacturing solutions that operate in the region through establishing a physical presence or through appointing agents. Suppliers also cover providers of 5G services, data centre services and cloud solutions, including industrial estate developers that have upgraded factory facilities with Industry 4.0 facilities. Some MNEs have also established centres of excellence or laboratory facilities. Some in collaboration with private and public local entities develop or are involved with R&D in advance digital technology solutions for manufacturing.

Some foreign suppliers of advanced manufacturing technology have forged partnerships among themselves to advance digitalization and application of smart manufacturing technologies in ASEAN. For instance, the partnership between ABB (Switzerland) and Ericsson (Sweden) in

Figure 3.5. Smart factories in ASEAN: Categories of actors

Category	What they do	Actors
User	• Exploit digital and connectivity technology to increase efficiency • Establish smart factories involving Industry 4.0 technologies	• Local firms • Foreign MNEs
Provider/ operator	• Develop and supply equipment and technology solutions • Develop digital infrastructure that enable connectivity (e.g. 5G) • Develop industrial parks with Industry 4.0 infrastructure	• Digital infrastructure companies (e.g. telecommunication, data centers) • Automation and IIoT solution providers (MNEs and local companies) • Cloud companies • Local firms in partnership with MNEs • Industrial estate developers
Institution	• Facilitate development and promotion of Industry 4.0 technology • Establish R&D and centers of excellence • Establish programme and centers for training and skills development on automation and Industry 4.0 technologies	• Universities • Dedicated institutions for Industry 4.0 • Public and MNE centres of excellence • Natioinal and MNE R&D centers

Source: ASEAN Investment Report 2020–2021 research, based on annex tables 3.5 and 3.6, industry reports and media.

Thailand entails ABB's robotics and discrete automation, IA and motion business services, while Ericsson provides 5G connectivity to prospective clients based in that host country. It also covers 5G-enabled augmented reality lenses for remote commissioning in manufacturing, in addition to IIoT technologies. The partnership of Hitachi Asia and Denso International Asia (both Japan) in Thailand develops digital solutions for manufacturing clients. Hitachi provides digital solutions for factory management, while Denso focuses on analytics solutions and data collection from factory automation equipment.

(b) MNEs with smart factories in ASEAN

Foreign MNEs in ASEAN are relatively more active than local companies in developing smart factories (box 3.13). Annex table 3.5 provides a list of smart factories which are growing in ASEAN. They include (i) manufacturers of Industry 4.0 technology hardware, such as automation machines and equipment, sensors and semiconductors (e.g. BBS Automation (Germany), Infineon Technologies (Germany), Micron Technology (United States) and Yamazaki Mazak (Japan)); and (ii) manufacturing companies that operate in the automotive, electronic, food and beverage industries, biotechnology (i.e. Akebono Brake Indonesia (Japan), Amgen (United States), Asmo Indonesia (Japan), Bosch (Germany), Hitachi (Japan), Hyundai (Republic of Korea), Nissan (Japan) and Toyota (Japan)).

These MNEs in ASEAN can be classified in three main groups:

(i) Companies from the United States, which are mostly involved in advanced technology, semiconductor manufacturing and biotechnology. In most cases they operate smart factories in Singapore.

(ii) Japanese subsidiaries that manufacture electronics, vehicles, automotive parts and components, precision engineering machinery and chemical products. These manufacturers tend to base their facilities in multiple locations: Indonesia, Malaysia, Thailand and Viet Nam. The Japanese manufacturing facilities are also the largest group that have integrated Industry 4.0 key technologies.

(iii) European companies that manufacture IA hardware, electrical components and advanced technology automotive parts. Similar to the Japanese manufacturers, most European manufacturers tend to have facilities in several ASEAN countries (Indonesia, Malaysia, Singapore, Thailand and Viet Nam). Bosch (Germany) has smart manufacturing facilities in Thailand and Schneider Electric (France) in Indonesia and the Philippines.

Three types of companies have established smart factories in ASEAN. They are all associated with MNEs operating in Industry 4.0-related technologies. The first type are smart factories established by MNE providers of advanced manufacturing technology (i.e. IA hardware and solution providers). These companies either upgraded manufacturing facilities or established smart factories to improve efficiency and to showcase how smart factories can be implemented and why. Subsidiaries of MNEs involved with smart factories in ASEAN include Schneider Electric (France), Bosch and Pepperl+Fuchs (both Germany), Hitachi, Yamazaki Mazak and Yokogawa (all Japan), ABB and STMicroelectronics (both Switzerland) and GE (United States).

Box 3.13. MNEs with smart factories in ASEAN

The number of smart factories in ASEAN is increasing, albeit concentrated in a few Member States. Foreign and local companies are establishing smart manufacturing plants. Some MNEs that have established smart factories in the region are highlighted below:

Afton (United States), a chemical manufacturer, opened a plant in Singapore in 2016 with a high level of automation and connectivity. The plant uses advanced distributed control systems to manage plant processes and utilities systems, ensuring safety and boosting productivity. It also has installed a remote machine-human interface, which reduces manual communications and human error.[a]

Bosch Rexroth (Germany) opened a smart factory (an injection plant) in Thailand in 2017. The factory relies heavily on connected manufacturing (highly automated) to serve international local customers in the growing automobile production industry.[b]

Denka (Japan), a major supplier of transparent polymers, reduced the cost of producing steam by 7 percent through applying IIoT and installing sensors on 148 steam traps at its chemical plant in Singapore. Denka worked with Emerson for its IIoT installation in 2016.[c]

Infineon (Germany), a semiconductor MNE, has a significant presence in ASEAN. It has invested more than $80 million in a smart factory in Singapore. The factory uses data analytics, advanced automation and IIoT, which has help reduced direct labour costs by 30 per cent and improve capital efficiency by 15 per cent. In 2020, Infineon launched a factory upgrade with a $27 million investment over the next three years to embed AI technology in every job function in its business and manufacturing operations.

Micron Technology (United States)[d] manufactures computer memory and computer data storage in Singapore. It has transformed its operation in the host country since 2014 from a simple environment using statistical analysis of production processes to a more complex system involving deep learning and AI capabilities to draw insights from factory operation data. The factory uses a network of sensors and IIoTs (e.g. cameras and acoustic equipment) to collect and analyse data for making real-time decisions to improve production efficiency. The digital transformation in manufacturing reduced scrap and product downgrades by 22 per cent. The application of advanced analytics to optimize processes reduced the time to ramp up new products by 50 per cent. Deep-learning optical-defect detection improved yield by 2 per cent, and the integrated deviation management platform reduced the time required to resolve quality issues by 50 per cent.

Schneider Electric (France)[e] is a supplier of smart factory solutions to manufacturing clients based in ASEAN. It started to operate a smart factory in Batam, Indonesia and in the Philippines in 2018. The Batam factory is also used as a showcase for clients of the benefits of digital transformation for making informed, data-driven decisions to achieve operational efficiency. The factory uses a wide range of IIoT technologies, including smart sensors, alarm prediction management, site benchmarking and augmented reality. It tracks operation performance in real time, which enables better visibility of machine performance and preventive maintenance needs. The Batam plant has helped the company reduce hours spent on maintenance by 17 per cent, waste material 46 per cent in less than six months and machine downtime by 44 per cent one year after its establishment. It is also a testbed for machine learning, AI, predictive and digital maintenance, and connected machines and processes.

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Box 3.13. MNEs with smart factories in ASEAN (Concluded)

Sumitomo Chemical (Japan) started a global IIoT project in Singapore in 2016 in cooperation with Accenture and with support from EDB.[f] The company has incorporated advanced technologies, including digitalizing plant-related operations and visualizing and upgrading global supply chain information. The expertise acquired in Singapore will be a reference for the roll-out of IIoT to the group's other global plants.

Sources: Company website and information, WEF global lighthouse network and media.
[a] Global Business Reports, "Special Report on Singapore", 2016 (https://www.gbreports.com/wp-content/uploads/2016/09/CW-Singapore-2016-v7-medres.pdf).
[b] *Digital News Asia*, "Bosch opens first smart factory in Thailand", 6 December 2017.
[c] *ARC Advisory Group*, "Sounding out an IIoT application in Asia", 1 June 2016.
[d] Micron Technology and WEF global lighthouse network.
[e] Schneider Electric and iaasiaonline (https://www.iaasiaonline.com).
[f] EDB Singapore.

The second type are smart factories established by MNE manufacturing subsidiaries to become more competitive, improve efficiency, reduce costs and better control production. These companies are mainly in the automotive, chemical, electronics and semiconductor industries. They include Infineon Technologies (Germany), Makino, Nissan, and Toyota (all Japan), Shell (Netherlands), Hyundai (Republic of Korea), Dyson (United Kingdom), and Afton, Amgen and Micron Technology (all United States).

The third type are smart factories owned by large ASEAN companies or ASEAN MNEs. These local companies in Indonesia, Malaysia, Thailand, Singapore and Viet Nam have built or transformed manufacturing facilities into smart factories with equipment and technology solutions provided by foreign MNEs. They include Chandra Asri Petrochemical, Garuda Food, Indolakto and Sritex (all Indonesia); Nationgate, Pentamaster and Vitrox (all Malaysia), Kulicke & Sofa (Singapore); Siam Cement and Utac Thai Group (both Thailand); and Vinamilk, Vinfast and Truong Hai Auto (all Viet Nam).

Most of the smart factories in the list in annex table 3.5 are owned by companies from Europe, Japan and the United States. Of the more than 60 smart factories (combining the foreign and ASEAN lists; i.e. combining annex tables 3.5 and 3.6), most are in Singapore, with significant numbers in Indonesia, Malaysia, Thailand, and Viet Nam.

(c) MNEs and local smart factories

Some ASEAN companies have started their Industry 4.0 transformation process with support from MNEs, by adopting advanced digital technologies and establishing smart factories (annex table 3.6). Most of these are large ASEAN corporations or conglomerates such as Chandra Asri, Kimia Farma, PT Garuda Food and PT Indolakto (all Indonesia), Pentamaster Corporation (Malaysia), PLC Industries (Singapore), Siam City Cement and Somboon Advance Technology (both Thailand) and VinFast (Viet Nam). Some have partnered with major foreign providers of Industry 4.0 technology: for example, Chandra Asri and PT Garuda Foods with Siemens, PT Asmo with Omron, Siam City Cement with Fujitsu, and Vietnam Soybean Milk Company with ABB. MNEs have played an active role in establishing smart factories for local companies, as examples from Indonesia, Malaysia and Thailand show.

Indonesia

PT Indolakto, a milk producer, built a factory in Purwosari in 2012 using IA technology, including advanced robotics supplied by ABB. Since 2016, IIoT was added to the manufacturing system, which can be accessed and controlled in real time by mobile phone. Distribution of products to franchise retail stores is interconnected with operations, enabled by IIoT connectivity. Inventory can be controlled and quickly replenished as indicated by the system. Through e-commerce, customers can buy goods using a mobile phone and products can be delivered to homes. Data on products sold flow directly in real time into a database and are analysed to identify any actions required.

PT Garuda Food (Indonesia) and *Barry Callebaut Group* (Switzerland) have operated a smart chocolate factory in Bandung, Indonesia since 2019. Automation technology, supplied by Siemens (Germany), monitors and controls production processes, provides early warning of machine breakdowns and observes the impacts on production of changing parameters. The system enables real-time monitoring and control of the production process through data analytics and devices that are connected and controlled digitally to ensure consistent performance and quality. The smart factory was built inside an existing factory (i.e. the Garuda Food Rancaekek biscuit factory), with an investment of Rp 40 billion.

PT Petrosea began the digital transformation of its mining operation in June 2018 with deployment of technology supporting optimization of truck dispatch, real-time performance monitoring and predictive maintenance. Smart sensor technology was installed to capture data (e.g. fuel consumption, driver performance and road conditions) for real time analytics and decision-making. Other smart technologies such as AI, big data, IoT and machine learning were also adopted.

Malaysia

SMART Modular Technologies, a specialty memory and storage solutions manufacturer, was supported by IBM (United States) in transforming and upgrading its Penang manufacturing operations for Industry 4.0 in 2019. This involved the deployment of AI-powered capabilities and re-skilling its workforce to use IBM's collaborative robots.[42] Prior to packaging finished products, the robots can spot defects and remove those products from the production line. IBM's engagement included introducing factory automation technology. IBM helped SMART develop and train AI-enabled collaborative robots to run test stations on the manufacturing floor to automate and improve testing capabilities.

Philippines

Integrated Micro-Electronics is a provider of electronics manufacturing services, power semiconductor assembly and test services. It is a member of the Ayala Group (Philippines). It has upgraded its production capacities with advanced manufacturing technologies such as through adoption of integrated and connected automation and robotic solutions from ASM and Baxter Robot of Rethink Robotics (both Germany) and Mitsubishi (Japan). It has also established relationships with other foreign industrial technology suppliers through its subsidiaries network.

For example, through PSI Technologies with PhD Inc (United States), Urban.io (Australia) and Allied Witan (United States) and through Optronics with Corning (United States) and VTS-Touchsensor (Japan). In another example, *Universal Robina Sugar Manufacturing Corporation* adopted technology solutions from Yokogawa (Japan) for an integrated automation system.

Singapore

PBA, a local manufacturer of precision bearings and factory automation solutions, adopted robotic automation technology from ABB (Switzerland). PBA built a 5,000 square meters smart factory for high mix low volume manufacturing utilizing robotics, automated vision inspection, factory automation and data analytics.

Thailand

Siam City Cement (Thailand) established a smart factory with a technology solution provided by Fujitsu (Japan). The factory is equipped with IIoT technologies that connect people, processes and machines. It has (i) a network of 374 Wi-Fi access points to help supervisors monitor and track the plant's operation, (ii) a remote operation centre and integrated digital communication technology, (iii) machine learning and predictive analytics for failure prognosis, and (iv) location-based control and safety measures for plant maintenance.[43] The smart factory enabled the company to significantly improve operational efficiency while enhancing safety and giving managers the information they need to achieve improvement in plant operations and performance. The company plans to deploy smart connected factory processes and technologies to its operations in other ASEAN countries (Cambodia, Viet Nam), as well as in Sri Lanka and Bangladesh.

Viet Nam

Some large local corporations in Viet Nam have also developed or transformed their manufacturing facilities into smart factories or smart manufacturing. They include Vinamilk, Vinacomin Motor Industries and VinFast in the manufacturing of vehicles (box 3.14). More foreign MNEs are also deploying Industry 4.0 technologies such as advanced robots, big data and AI to establish smart manufacturing facilities in Viet Nam (table 3.37).

Box 3.14. VinFast Automotive Manufacturing

VinFast (Viet Nam) has developed smart factories that connect advanced manufacturing technologies supplied by MNEs such as Duerr, Eisenmann, Grob, MAG, Scheuchl, Schuler and Thyssen Krupp (all Germany), ABB (Switzerland) and AVL (Austria).[a] ABB supplied a complete welding solution of robots, positioners and power sources and full commissioning service; Norgren (United Kingdom) provided tooling solutions; and Siemens (Germany) provided a closed-loop manufacturing system that uses digital twins of the products and the production system.

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Box 3.14. VinFast Automotive Manufacturing (Concluded)

VinFast built an Industry 4.0 manufacturing facility in 2019 that involves five factories. The facility uses Industry 4.0 technology that connects machines, devices, production lines and automation through cloud computing and the internet. The factories are automated and interact with each other to minimize damage and maximize productivity on the production line, including the stamping, car body welding, painting, engine and finishing assembly shops. The facility also incorporates applications such as device monitoring, optimized production process optimization, device optimization, maintenance management, flexibility and adaptability. It has 1,200 ABB-manufactured robots.[b] The link between robots, humans, and machines and equipment is complete with Industry 4.0 application. In the painting shop, which is equipped with 79 robots, robotic controllers check and forecast repairs and maintenance, to avoid emergency shutdowns.

The entire value chain (i.e. press, body, paint, assembly and engine shops) has been integrated and digitalized with Siemens' Digital Enterprise production software and hardware.[c] The portfolio includes (i) the development of digital twins of the production process with test data and performance analytics, (ii) computer-aided design, manufacturing and engineering, (iii) and team center software that allows product lifecycle management.

Sources: VinFast, industry reports and media.
[a] *Vietnam Investment Review,* "Adopting smart manufacturing lines", 10 October 2019.
[b] *Creative Engineering,* "The factory of VinFast has a standard technology of the Industry 4.0 with up to 1,200 robots", 17 July 2018.
[c] *Automotive Manufacturing Solutions,* "VinFast deploys Siemens tech in new plant", 16 September 2019.

Table 3.37. Smart manufacturing facilities in Viet Nam (Selected cases)

Name	Year	Investor	Main products	Investment
ABB Tien Son High Voltage & Medium Voltage Factory	2010	ABB Group (Switzerland)	Compact substations, switchgears	$30 million
Nestle Bong Sen Factory (factory #6 of Nestle in Vietnam)	2017	Nestle Group (Netherlands)	Diary products	$100 million
Texhong Yarn Factory	2013	Texhong Group, (Hong Kong, China)	Yarn and garment fabrics	$300 million
Vietnam Piaggio Scooter Plant		Piaggio Group (Italia)	Scooters	..
Honda-Vietnam Motorbike Plant	2014	Honda (Japan)	Scooters/motorbikes	$120 million
GE Haiphong	2009	GE (United States)	Wind-turbine generators and electrical control system components	$111 million
Henkel Adhesive Technologies Vietnam	2000	Henkel Adhesive Technologies (Germany)	Adhesive solutions	..
Samsung Display Vietnam	2015	Samsung (Republic of Korea)	Electronics	$6.5 billion[a]
Daikin Air Conditioning (Vietnam)	2018	Daikin Global (Japan)	Air conditioners	$72 million
Fujikura Fiber Optics Vietnam	2000	Fujikura Global (Japan)	Fiber optic components	..

Source: *Vietnam Investment Review.*
Note: The list is compiled from smart manufacturing solution vendors, which may include some smart factories. The smart manufacturing in these factories is characterised by adoption of advanced robots, big data for predictive maintenance and AI for quality control or color matching (textile).
[a] Total investment in Viet Nam.

3.6.3. Digital twins

A digital twin is a digital representation of a physical object or system. It can include a digital replication of a factory, building or cities. The strength of the digital twin is its visual, data and analytics capabilities. A smart factory can benefit from the application of digital twin technology and IIoT to support remote real-time decision-making, but such application in manufacturing in ASEAN is limited. Cost is a major hindrance. The limited technological capacity of many manufacturers to optimally benefit from such an advanced and sophisticated system is another deterrent.

Nonetheless, some MNEs and ASEAN companies are adopting digital twins, which involves digitalizing their entire operations and production systems. In Singapore in 2020, Royal Dutch Shell started a four-year pilot project to digitalize its Pulau Bukom refining complex. When fully implemented in 2024, the technology will generate a complete virtual twin of the physical elements on the oil and petrochemical manufacturing site. This will enable operators to respond in real time to changes in conditions at the complex. The digitalization of Pulau Bukom will use automation powered by data to perform everyday tasks. Shell also intends to transform its Jurong facility with advanced digitalization technologies.[44]

In Indonesia, *Chandra Asri Petrochemical* is being supported by Siemens (Germany) and Bentley Systems (United States) in constructing the company's first petrochemical digital twin of a manufacturing facility. The development and implementation of the digital twin will be complete by 2025. The digital twin will provide visualization of data on plant assets and engineering functions. It will involve IIoT, real-time analytics and AI technologies. The information will be accessible through an integrated digital platform.[45] *PT Waskita Karya*, an Indonesian State-owned construction company, established a digital twin facility. The digital twin provides a representation of all construction projects carried out by the company to simulate scenarios and to collect data in the field. Waskita Karya's digital transformation began with its toll road construction business unit to support the government program for national economic recovery and accelerate infrastructure development during the pandemic.[46] The company worked with Bentley Systems (United States) in the development and installation of the digital twin solution. By establishing a digital twin, Waskita was able to identify and resolve conflicts prior to construction, avoiding on-site problems and save an estimated 0.3 per cent per month in additional time and costs.[47]

Some Malaysian companies are also leveraging digital twin technology to improve efficiency. *Lebuhraya Borneo Utara*, the project delivery partner of the Pan Borneo Highway project, is responsible for integrating design and construction data with asset performance technology to manage operation and maintenance. It uses digital solutions from Bentley (United States) to achieve a digital twin to support asset performance and management needs. The digital twin spans project delivery and operations, capitalizing on the full potential of data analytics in real-time (for information on operation, maintenance and engineering).

A growing number of MNEs in Singapore are adopting a portfolio of Industry 4.0 technologies to establish digital twin of the plants (table 3.38).

Table 3.38. Digital twins in Singapore (Selected cases)

Name	Industry	Industry 4.0 technologies	Key Industry 4.0 activities
ABB	Machinery & Equipment	• Digital twin • Advanced analytics • IIoT	• ABB's RobotStudio simulation software is used in creating a digital twin, which allows users to adjust robotic installation • A high-precision automated laboratory system (RAVE) was used to automate the testing of COVID-19 samples
Bosch Rexroth	Electronics	• Digital twin • Collaborative robots (co-bots) • Industrial IoT / cloud • Advanced analytics	• Created digital building twin, enabled by Microsoft Azure Cloud Services • Used cobots in human-machine collaboration approaches to production • Used IIoT gateway kit including a complete ecosystem from sensor to cloud solutions, software and MEMs sensors
Continental Automotive	Automotive	• Digital twin • Advanced analytics • Robots / AGVs • IIoT	• Implemented digital twins in Penang and China from Singapore. The system, set up one year before standard operating procedures for actual production, effectively compressed manufacturing development lifecycle
dormakaba	General Manufacturing	• Digital twin	• Simulated painting production line as a fully functional virtual facility months before constructing its new Singapore plant, which was then refined and used as a blueprint for the physical counterpart. • Optimised production scheduling by simulating increased throughput, speedier color & model changes, and minimize operational disruptions.
GlaxoSmithKline (GSK)	Pharmaceuticals	• Digital twin • AI • IIoT • Advanced analytics	• Scientists and engineers are working on building a digital twin in Singapore plant, which will virtually simulates the production process of vaccines, using an intuitive graphic interface
Infineon	Semiconductors	• Digital twin • Robots • Advanced analytics, predictive maintenance • IIoT	• Partnered with HOPE Technik to develop Automated Guided Vehicles (AGVs) to transport resources across Infineon's factory floor • Invested S$105 million to transform operations in Singapore into a smart factory
Micron	Semiconductors	• Digital twin • IIoT, cloud computing • AI	• Micron uses AI to spot temperature anomalies by analyzing infrared photographs that generate "heat maps" of the factory, and overlaying images captured from usual working conditions over a fab's digital twin for comparison
Rolls Royce	Aerospace	• Digital twin • Advanced analytics • AI	• Signed an MOU with DSTA to develop digital twins for aircraft engines which allows the simulation of different scenarios to tweak engine design
Royal Dutch Shell	Energy & chemicals	• Digital twin • AR / VR • 3D printing • Drones • Advanced analytics	• Piloted a digital twin of its Pulau Bukom manufacturing plant with full implementation by 2024 • Plans to drive automation based on machine learning analysis of data collected
SATS	Food & beverage / logistics	• Digital twin	• Used Dassault Systèmes' 3DEXPERIENCE platform on the cloud to create the world's first digital twin of a kitchen, bridging the gap between virtual and real in-flight catering. Data collected is used for better resource planning

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Table 3.38. Digital twins in Singapore (Selected cases) (Concluded)

Name	Industry	Industry 4.0 technologies	Key Industry 4.0 activities
Schneider Electric	Electronics	• Digital twin • IIoT, cloud • Advanced analytics • AI	• Utilising the Microsoft Azure cloud service, Schneider developed a digital twin of Frasers Tower in Singapore as a model for smart offices, leveraging its own sensor technology and Ecostruxure platform
Siemens	Electronics / MedTech	• Digital twin • IIoT, cloud • Advanced analytics • AI	• Opened its first digitalisation hub in Singapore on the MindSphere platform, simulating production line and other assets to form a fully-functional, closed-loop digital twin (a virtual digital representation of its advanced manufacturing plant) • Collaborated with Advanced Remanufacturing and Technology Centre (ARTC) to provide technology solutions for test-bedding • Signed Memorandum of Understanding with industry partners to establish the Pharma Innovation Programme Singapore (PIPS)
Tetra Pak, in collaboration with DHL Singapore	General manufacturing; logistics	• Digital twin • IIoT • Advanced analytics	• DHL Supply Chain worked with Tetra Pak to implement its first digital twin warehouse in APAC, developing an integrated supply chain solution. • Maintenance of 24/7 coordination of its operations to resolve issues real-time; includes control tower which monitors the flow of goods to maximise efficiency

Source: Tan et al. (2021).

PTTEP, a Thai State-owned enterprise in petroleum exploration and production, awarded Halliburton (United States) a contract in 2020 to supply and install various types of digital technologies including an open architecture, hybrid cloud and a digital twin facility. A software solution from Honeywell (United States) to provide real-time data and visual intelligence will be used. The digital transformation aims to improve efficiency and increase production, reduce operating expenses and maximize the value of PTTEP's portfolio.[48]

3.7. CONCLUSION

This chapter has provided evidence of how MNEs are playing a role in Industry 4.0 transformation in ASEAN. They contribute to the development of the digital ecosystem and in key segments of the Industry 4.0 value chains, from building digital infrastructure to providing IA and IIoT technology, including 3D printing solutions, to the manufacturing industry. This transformation is nascent but advancing.

Member States that have a strong manufacturing industry tend to see more MNEs adopting and investing in Industry 4.0 activities. Increasing interest in upgrading IA technologies, government advocacy for Industry 4.0 transformation and a strong commitment to digital infrastructure development are key factors supporting the rise in digital investment. A growing pool of manufacturers planning to adopt technologies and an improving digital ecosystem are additional reasons.

Foreign MNEs are playing an important catalytic role in the transformation process as investors, suppliers, users and developers of hardware and software solutions, including in providing skills development and training. These MNEs are digitalizing manufacturing plants, using advanced manufacturing technologies and establishing R&D facilities, technology hubs and centres of excellence in the region. As investors, many have established a significant presence in ASEAN to build digital infrastructure, manufacture industrial automation hardware and supply technology solutions to clients in a vibrant manufacturing environment and a rapidly growing regional digital economy. Many have also upgraded their plants with Industry 4.0 technologies. Some have established smart factories, including deployment of digital twins. The presence of these MNEs is a testament to the growing importance of the region for FDI in Industry 4.0 activities.

The top 50 global IA MNEs and 44 of the top 50 global IIoT MNEs operate in the region. Many have established a significant presence in multiple ASEAN Member States. Most are involved with various business functions, from sales and distribution to manufacturing and subsidiaries, providing advanced industrial digital technology solutions. Foreign telecommunication infrastructure companies are participating in the region's 5G development, which is important for connectivity and to support more efficient application of Industry 4.0 technologies. Many major global operators of data centres and technology MNEs have established multiple facilities in the region because of the rapid rise in demand for data centre and cloud facilities. All but three of the top 15 global data centre co-location providers, all but one of the top 15 global cloud MNEs, and major additive manufacturing MNEs headquartered in Europe, Japan and the United States are in ASEAN. The presence of these MNEs in different Industry 4.0 technology segments is strengthening regional and national digital ecosystems and the manufacturing environment.

Subsidiaries of MNEs are often better equipped to adopt Industry 4.0 technologies than are local companies because of their relatively stronger financial and technological capacities, and the influence of their parent companies' adoption of technology. MNE demonstration effects are also encouraging other companies (local and foreign) to adopt Industry 4.0 technologies,

especially SMEs that have vendor relationships with MNEs. Some large local companies are adopting Industry 4.0 technologies, with MNEs supplying equipment, technology solutions and installation of these technologies in new or existing plants. An increasing number of local companies have established smart or intelligent factories. Some have even adopted digital twin technologies to enhance control of operation and increase digitalization of manufacturing.

The investment prospects for Industry 4.0 development in ASEAN are promising. This stems from the strong commitment of all countries in the region to deliver 5G networks, rising demand for Industry 4.0 technologies from manufacturing and digital services industries, favourable government policies and measures supporting Industry 4.0 transformation, and the rapidly growing digital economy. These market factors, improving digital ecosystems and the drive from MNEs to upgrade technological production capacities are expected to accelerate the growth of FDI in Industry 4.0 by 2025 and beyond. Lessons from the pandemic related to the disruption of supply chains could further accelerate digital adoption in the manufacturing industry.

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CHAPTER 4

Industry 4.0 Plans, Actions and Policy Options

4.1. INTRODUCTION

Although Industry 4.0 adoption in ASEAN is at a nascent stage, more companies (local and foreign MNEs) are recognizing its significance and are planning to adopt Industry 4.0 technologies in the next five years. ASEAN Member States are actively promoting Industry 4.0 transformation to boost the region's manufacturing potential and to improve efficiency and productivity.

Member States recognize the role that MNEs and FDI can play in supporting the realization of Industry 4.0 transformation. Some have adopted national plans for the transformation and have specific policies and measures to attract FDI in it.

In addition to national plans and actions, Member States have also cooperated at the regional level on Industry 4.0 matters through agreements, action plans and declarations. These efforts include cooperation on promoting the digital economy, Industry 4.0 transformation, cybersecurity, e-commerce and smart cities development.

This chapter analyses actions taken at the regional and national levels to support Industry 4.0 transformation in relation to FDI and MNE activities. It also examines how Industry 4.0 affects the ability of ASEAN to attract FDI, how it alters the investment environment and how FDI in related digital activities is shaping the Industry 4.0 landscape in ASEAN. This chapter offers policy options to address bottlenecks in attracting FDI in Industry 4.0.

4.2. INDUSTRY 4.0 ADOPTION IN ASEAN

The adoption of Industry 4.0 technologies in ASEAN, albeit growing, is uneven across Member States. It is also characterized by other key aspects. First, the degree of readiness for Industry 4.0 transformation is linked to the development stage of the Member State. In some the industrial capacity and the stage of technological development are at Industry 1.0 (basic mechanization) to 2.0, while some are making robust efforts to push towards Industry 4.0 (box 4.1). In monitoring transformation, some Member States have developed an Industry 4.0 index to measure the progress of development towards Industry 4.0.

Box 4.1. State of application of Industry 4.0 technologies in the Philippines, Thailand and Viet Nam

Recent surveys assessing the Industry 4.0 readiness of firms in the Philippines, Thailand and Viet Nam found that most firms – mainly small and medium-size enterprises (SMEs) – are at the Industry 1.0 state of technology use (purely manual and basic mechanization). Large local firms and MNEs are more technologically mature and are at Industry 3.0, moving towards Industry 4.0. Some have already adopted Industry 4.0 technologies.

Philippines

The manufacturing industry in the Philippines has a low rate of technology adoption. In 2020, the Department of Trade and Industry surveyed 144 firms (53 per cent of them large companies) on the state of Industry 4.0 adoption. More than 50 per cent of the respondents control and track manufacturing activities manually; 58 per cent have no manufacturing equipment connected to the network; and 65 per cent do not use technology to ensure production quality. For the majority, cybersecurity was identified as a knowledge gap (Aldaba 2020). SMEs' use of technology is at the Industry 1.0 level (purely manual). Large companies, MNEs, firms that locate in economic zones (AIR 2017), and exporters have relatively better rates of technology usage. In every dimension of manufacturing, the technology use scores for these companies is less than Industry 4.0. Higher rates of technology use are found in the paper, computer, electronics, automotive and pharmaceutical industries. Traditionally important industries such as textiles, leather, garments and beverages have the lowest scores. The respondents were also asked about their awareness of and familiarity with Industry 4.0: large enterprises (80 per cent) indicate a high level of awareness, while fewer SMEs (33 per cent) are familiar with Industry 4.0; far fewer micro-sized enterprises are aware of it.

Thailand

The Digital Economy Promotion Agency (DEPA) of Thailand conducted a survey in 2020 of 601 companies in five industrial sectors. The survey showed that most local firms are in the Industry 1.0 stage. More than 80 per cent of surveyed firms in traditional industries (i.e. processed agriculture products, and textiles and garments) use unsophisticated digital technologies together with analogue technologies to manage five business functions: supplier relationships, product development, production, client relationships and business administration (box table 4.1.1). However, in three industries where foreign firms are more prominent – automotive, electrical and electronics, and machinery – most firms are at Industry 2.0, with a small number already advanced into Industry 3.0 or 4.0. MNEs are investing in Industry 4.0 activities in Thailand, but the adoption and development of Industry 4.0 technologies remains low. During 2010–2019, firms registered 3 655 patents, which were mostly related to Industry 4.0 technologies.[a] This number accounted for only 7 per cent of all patents registered in the country during the period. Foreign companies own most of these patented technologies; 83 per cent of these patents were applied for by foreign companies. Cybersecurity followed by user interface and data security have the most patents.

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Box 4.1. State of application of Industry 4.0 technologies in the Philippines, Thailand and Viet Nam (Concluded)

Box table 4.1.1. Application of digital technologies in Thai industries

Industry	State of application of digital technologies
Food and processed agriculture	80 per cent of firms are in the Industry 1.0 stage in applying digital technologies to all five business functions.
Textiles/garment	80 per cent of firms applied simple digital technologies together with manual systems (Industry 1.0) in five business functions.
Automotive	More than half are still in Industry 2.0. About 20–25 per cent of firms applied Industry 2.0 in product development (computer-aided design and computer-integrated manufacturing), process management and customer relationship. Less than 10 per cent are in Industry 3.0.
Electrical and electronics	One third of firms applied computer-aided design and computer-integrated manufacturing in product development (Industry 2.0). About 5 per cent used integrated data product systems (Industry 3.0). However, process management in most firms is still in Industry 1.0.
Machinery and parts	About 40 per cent of firms applied computer-aided design and computer-integrated manufacturing in product development (Industry 2.0). However, more than 80 per cent still use simple digital technologies with the manual systems for customer relationship and business management (Industry 1.0).

Source: Survey on Application of Digital Technologies in Thai Industry in 2020, DEPA.
Note: Based on a survey of 601 companies in five key industries (food and processed agriculture, 27 per cent of respondents; automotive, 28 per cent; textiles and garments, 15 per cent; electrical and electronics, 15 per cent; and machinery and parts, 15 per cent). Some 73 per cent were local manufacturing companies, and 23 per cent were foreign firms. The sample consisted of small firms (25 per cent), medium-size firms (34 per cent) and large firms (41 per cent).

Viet Nam

In April–May 2021 the Vietnam Investment Review conducted a survey of 211 firms, of which 91 were in manufacturing. The survey showed that more than 70 per cent of firms have invested or started to invest in basic digital technologies (e.g. cybersecurity, enterprise resource planning and cloud computing). A minority have invested in advanced smart manufacturing technologies such as big data analysis, the internet of things (IoT), robotics and artificial intelligence (AI). As targets of intention to invest in Industry 4.0 technologies over the next three to five years, digital infrastructure received the highest priority, followed by e-commerce platforms and robotics/automation. The IoT and AI, which are essential foundations for smart manufacturing, received only low priority. This suggests that while manufacturing companies are significantly increasing investment in digital transformation, the pace of their transformation towards Industry 4.0 remains modest. Barring substantial promotion, then, smart manufacturing is unlikely to become a prevailing trend in the manufacturing industry over the next three to five years.[b]

Source: ASEAN Investment Report 2020–2021 research, based on Albert and Quimba (2021), Intarakumnerd (2021) and Vu (2021).
[a] Based on data from the Department of Intellectual Property (2021).
[b] Based on a country paper prepared for *AIR 2021*.

Second, both local and foreign firms have evinced growing interest in recent years in moving towards automation and adoption of Industry 4.0 technologies (table 4.1). However, foreign firms are more inclined than local firms to adopt Industry 4.0 technologies to improve efficiency. Large local firms are relatively more open to adopt Industry 4.0 technologies than small and medium-sized enterprises (SMEs).

Third, some industries are more ready to adopt Industry 4.0 technologies because of precision manufacturing, replacing repetitive manual tasks with automation and smart technologies, and to advance towards achieving a condition that supports effective coordination and utilization of a portfolio of digital technologies to improve efficiency. These industries include automotive, electronics and food processing (box 4.2).

Table 4.1. Findings of selected studies on Industry 4.0 in ASEAN

Key finding	Asia Robotics Review (2019)	McKinsey (2018)	A.T. Kearney (2018)	A.T. Kearney/ World Economic Forum (2018)	Business Sweden (2019)	Ernst & Young (2019)	Singapore Industry 4.0 Readiness Index (SIRI)
Most companies in ASEAN are aware of the benefits and advantages of Industry 4.0.	✓	✓	✓	✓	✓	✓	✓
Companies are slowly adopting Industry 4.0 technologies.		✓	✓	✓	✓	✓	Varying rate across subsectors
Many companies, including SMEs, have plans for a technology shift in the next three years (especially AI, the IoT, advanced automation).		✓			✓	✓	
Foreign multinationals in ASEAN are more active in Industry 4.0 transformation.		✓	✓			✓	✓
Adoption of Industry 4.0 technologies presents opportunities to technology suppliers (mostly MNEs).	✓	✓			✓		✓
Challenges in adopting Industry 4.0 technologies include the following: (a) enduring low labour costs (b) high initial investment costs (c) difficulties accessing required experts (d) complex and fragmented supplier ecosystem (e) cybersecurity threats (f) lack of technical skills and know-how and difficulties in reskilling staff (g) infrastructure barriers		✓	✓		✓	✓	✓

Source: *ASEAN Investment Report 2020–2021* research, based on various studies.

Note: AI = artificial intelligence, IoT = internet of things, MNE = multinational enterprise, SMEs = small and medium-sized enterprises. These surveys and reports mostly cover firms in six ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam).

Box 4.2. Increasing adoption of Industry 4.0 technologies in some industries in ASEAN

The demand for Industry 4.0 technologies such as robots and automation systems in some industries in ASEAN is rising. For instance, Indonesia's food and beverage industry has increasingly been adopting the use of robots. Packaging is an important part of the manufacturing process in the industry. For repetitive packaging processes involving intensive manual steps, robotic technology provides an ideal solution. Omron (Japan) has been collaborating with Indonesian food and beverage companies in providing robotic solutions to save costs, shorten the supply cycle of goods and increase productivity.[a] According to ABB (Switzerland), in Indonesia 60 per cent of the industry used robots for production processes in 2019.[b] Half of ABB robots produced and marketed in Indonesia went to the food and beverages industry. The rest went to the automotive, plastic, metal and petrochemical industries.[c]

The Thai automotive industry, which has a significant presence of foreign original equipment manufacturers, has been adopting the use of industrial robots to support production processes. In 2019, Thailand was ranked 13th in the world in annual installation (flow) of industrial robots. Most robots installed were in the automotive industry. For instance, more than 50 per cent of robots installed in the country in 2017 were in the automotive industry, much higher than the 36 per cent share in Japan and the 39 per cent share in the Republic of Korea (International Federation of Robotics, 2017). Robotization has been adopted over recent years not only by major global automotive manufacturers in Thailand but also by foreign and local tier-1 part and component suppliers. MNEs act as lead firms, spearheading the introduction and adoption of technology and creating demonstration effects for local tier-1 suppliers (Intarakumnerd, forthcoming).

In Viet Nam, the adoption of industrial robots is increasing. There were about 15,900 robots in the country as of 2019 (15 per cent higher than in 2018), ranking the country 17th for its stock of robots. Most installations took place in the manufacturing industry and in recent years. Firms in Viet Nam installed 14,562 industrial robots during 2014–2019, which accounted for 91 per cent of the country's total robot stock; manufacturing accounted for 82 per cent of these robots. The electrical and electronics industries accounted for 74 per cent of robots newly installed in manufacturing firms in 2014–2019; it was followed by the plastics and chemical products (11.6 per cent) and the automotive (8.7 per cent) industries. The food and beverage and metal industries have accelerated in automation, with a notable increase in robot installation in 2018–2019. The textile, leather and garments industry, which accounts for nearly 50 per cent of Viet Nam's manufacturing employment, appeared to not have made any significant efforts towards automation.

Sources: Asia IoT Business Platform, International Federation of Robotic, company websites, industry reports and media.
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Fourth, the pandemic has accelerated the pace at which local and foreign firms in ASEAN automate and increase their use of digital technologies for both front-end (e-commerce and digital platforms) and back-end (manufacturing and manufacturing services) operations (chapter 3).

Fifth, many challenges lie ahead in the Industry 4.0 transformation journey. They can vary significantly between Member States; much depends on the technological capacity, digital development and investment ecosystems. Some Member States are in a better position to attract FDI in Industry 4.0, while others will face stronger challenges because of weaker investment environments or digital ecosystems. Policy options to address the social impact of the transformation, such as its impact on labour and on skills development, are required. Challenges impeding adoption of Industry 4.0 technologies, such as the requirements for seamless digital connectivity, cybersecurity, skills and digital infrastructure development need to be considered. Most Member States are addressing some of these infrastructure barriers by upgrading and attracting investment in 4G and 5G networks and data centres with the involvement of private investment, including FDI.

Sixth, the low but growing rate of Industry 4.0 adoption suggests opportunities for FDI and businesses in digital value chains, from infrastructure investment to manufacturing of equipment and supply of technology solutions. FDI and MNEs are important catalysts for the transformation. Recognizing this role and its impact on industrial upgrading, ASEAN Member States are keen to attract FDI in digital and Industry 4.0 activities; however, challenges impede this effort.

Two major areas of challenges could affect efforts to attract FDI in Industry 4.0: (i) those hampering adoption of Industry 4.0 technology, and (ii) those relating to attracting FDI in Industry 4.0 (table 4.2). These challenges are intertwined, underpinned by the symbiotic relationship between adoption of Industry 4.0 and the FDI environment (section 4.4).

Table 4.2. Challenges in attracting FDI in Industry 4.0 (Selected cases)

Challenge area	Description	Examples of needs
Digital infrastructure	Lack of digital infrastructure and connectivity, limiting capacity to attract FDI in Industry 4.0	• ICT connectivity (including undersea cable links) • Data centres • 4G-5G networks • Hyperscale broadband
Human resources and skills	Lack of human resources with Industry 4.0 technology skills set	• Supports ASEAN telecommunication operators in building ICT connectivity, including 5G networks. • A specialised institution to oversee and monitor the skills needed
Institutional support	Lack of coordinating institutions to promote Industry 4.0 and FDI in related sectors	• A coordinating institution that understands the complex issues of Industry 4.0
Policy direction	Lack of clear or targeted policy for promoting related FDI and adoption of Industry 4.0 technologies (e.g. automation, the IIoT)	• Targeted investment incentives • Targeted technology and innovation policy • Intellectual property protection • Ecosystem development, including policy promoting public-private partnerships in innovation

Source: ASEAN Investment Report 2020–2021 research, based on analysis in section 4.4.

Challenges in adopting Industry 4.0 (e.g. the slow adoption rate, lack of digital infrastructure and cybersecurity concerns) could affect the demand for Industry 4.0 technologies (i.e. affecting market-seeking FDI), the development of the digital ecosystem (i.e. a significant determinant of FDI in Industry 4.0) and the investment environment. For instance, challenges in adoption arising from the lack of Industry 4.0 skills and human resources in ASEAN could affect the attraction of FDI in R&D, technology centres and centres of excellence, which are important for industrial upgrading. The lack of skilled human resources could hamper efforts in the Industry 4.0 transition and in attracting related investment (e.g. those aiming to develop technology solutions) or in attracting the talent needed to operate and maintain advanced and connected technologies in MNE factories (e.g. smart factories or digital twins). The limited skills of the workforce in Industry 4.0 technologies remains a major challenge for all Member States, which has implications for both adopting Industry 4.0 and for attracting FDI in it.

The lack of a conducive digital ecosystem (e.g. the lack of clusters of technology providers) could impact on attracting FDI in Industry 4.0 such as in manufacturing and training centres. Some Member States faced challenges associating with the lack of industrial infrastructure to support Industry 4.0 activities. This includes limited digital infrastructure (5G, ICT connectivity and data centres) and the lack of specialised Industry 4.0 or upgraded industrial parks. In addition to lacking supportive infrastructure, some Member States lack clear FDI policy targeting Industry 4.0 activities.

The low adoption of Industry 4.0 technologies by SMEs is a major challenge, which could affect the ecosystem and the efficiency of the manufacturing industry because SMEs are significant players for the development of supporting industries. SMEs (foreign and local) face more challenges in upgrading factories because of associated costs and the companies' financial limitations. The lack of knowledge on how technology could be applied has also hampered Industry 4.0 adoption. Much labour-intensive FDI in Cambodia, the Lao People's Democratic Republic and Myanmar is motivated by access to a low-cost labour force. MNEs or SMEs involved in these investment activities are less inclined to upgrade factories with advanced technologies.

Although many of the challenges are country-specific, regional policy options could also be considered to promote investment and advance the development of the Industry 4.0 ecosystem so as to attract FDI (section 4.3.2).

4.3. INDUSTRY 4.0 PLANS AND FDI-RELATED MEASURES

Some Member States are moving ahead with Industry 4.0 initiatives (e.g. Indonesia, Malaysia, Singapore, Thailand), while others are developing transformation plans (e.g. Philippines, Viet Nam), and a few are just beginning to map out their digitalization path (e.g. Cambodia and the Lao People's Democratic Republic). A few have adopted specific policy measures aimed at attracting FDI in Industry 4.0 (figure 4.1).

Figure 4.1. National Industry 4.0 plans and FDI measures for digital and specific Industry 4.0 activities, by ASEAN Member State

Country	National Industry 4.0 plan	General measures to attract FDI in digital activities[a]	Industry 4.0 FDI-specific measures
Brunei Darussalam	Being planned	●	○
Cambodia	Being planned	●	○
Indonesia	●	●	●
Lao People's Democratic Republic	Being planned	●	○
Malaysia	●	●	●
Myanmar	Being planned	●	○
Philippines	◐	●	◐
Singapore	●	●	●
Thailand	●	●	●
Viet Nam	◐	●	◐

Source: ASEAN Investment Report 2020–2021 research, based on government websites and country information.

[a] Covered in national development, such as in information and communication technology and other investment measures that target digital activities, such as in e-commerce.

○ = Not yet.

◐ = Some aspects.

A few salient points on national Industry 4.0 plans in ASEAN can be highlighted. First, while some Member States have a clear plan (e.g. Indonesia, Malaysia, Thailand and Singapore), others are still developing plans (e.g. the CLMV countries, Cambodia, the Lao People's Democratic Republic, Myanmar, Viet Nam). All Member States recognize the importance of Industry 4.0 to strengthening efficiency and competitiveness and for industrial upgrading. The intensity of policy support and the scope of coverage of technologies to attract differ with different degrees of technological development, productive capacity and digital ecosystems.

Second, a few Member States are in a good position to attract digital enablers such as data centres and cloud facilities, while others are not. Those that are in a good position to do so (e.g. Indonesia, Malaysia, Singapore) have specific plans and measures, with the goal of attracting FDI from these enablers. Attracting these enablers would remain a challenge for other Member States (e.g. Brunei Darussalam and the CLMV countries) because of their market size, opportunities for scaling up, state of infrastructure support and because of lack of interest by MNEs in some of these countries.

Third, some Member States have developed efficient industrial facilities such as technoparks, specialized industrial parks, industry-specific infrastructure and promote knowledge and technology clusters (i.e. to facilitate agglomerations of research and development (R&D) centres, science parks, technology hubs, centres of excellence and dedicated government institutions). Others still lack such facilities or are developing them (e.g., the CLMV countries).

Fourth, countries differ in their use of the Industry 4.0 Readiness Index as a tool to assess the state of Industry 4.0 adoption by industry. Such differences limit the capacity to assess Industry 4.0 transformation at the regional level and impede efforts to identify policy to advance Industry 4.0 development in ASEAN.

At the regional level, Member States are increasing cooperation in promoting Industry 4.0 transformation, including in e-commerce development and cybersecurity resilience (section 4.3.2).

4.3.1. National Industry 4.0 plans and FDI-related measures

All ASEAN Member States have national development plans. Within these plans they have set specific targets for promoting the information and communication technology (ICT) sector. This section highlights major national Industry 4.0 plans and FDI-related measures of each Member State.

Brunei Darussalam's Vision 2035 includes ICT as part of the national strategy to realize the Vision. Development of the ICT sector is critical to building an ecosystem that supports Brunei Darussalam's long-term digital transformation. In 2019, the Government launched an initiative to develop the country's digital economy. In January 2020, it launched Go Live, an ICT initiative to support progress towards becoming a "smart nation", with a national digitally connected environment.

The Government has identified five clusters for investment priority, which include ICT (covering data centres, digital media, the IoT and biotechnology).[1] To promote investment in these clusters, full foreign ownership and operation of companies in these clusters is allowed. Investment incentives for qualified projects include exemption from corporate income tax for five years with the possibility of two extensions of three years each (for a total of 11 years), exemption from import duties for plants and equipment, and a fast-track FDI application system. The Government also promotes investment relating to the creation of regional hubs for ICT (a disaster recovery centre and projects involving emerging technologies in health care, advanced manufacturing processes and electronics).

Cambodia has announced plans to become an upper-middle-income country by 2030 and a high-income country by 2050. The Government is prioritizing the adoption of new technologies in manufacturing and encouraging investment in industries that are undergoing rapid technological innovation. It aims to ensure that the country can adapt and transform in line with technological change while minimizing the social and economic costs of transitioning.

Cambodia's Industrial Development Policy (2015–2025) encourages private sector participation in technological innovation. It covers reforming the education system to enhance the role of science, technology, engineering and math (STEM) education and promoting entrepreneurship and soft skills training. The Government adopted a Law on E-commerce on 2 November 2019, Sub-decree 134 on the determination of type, formality and procedures for issuing approvals or license to intermediaries and electronic commerce services providers and exceptions on 27 August 2020 and E-Commerce Strategy on 25 November 2020. The Cambodia Digital Economy and Social Policy Framework (2021–2035) was also adopted in 2021.

While Cambodia has taken these steps towards technological innovation and transformation, it faces challenges in moving to Industry 4.0 (UNDP, 2020). They include a shortage of STEM professionals; underdeveloped cybersecurity, data protection and data privacy regulations; limited internet services; a lack of data infrastructure; and a shortage of workers with digital skills. Tapping the potential of new technologies to upgrade and diversify the economy could assist in the transformation.

The Government has identified priority sectors for investment, which include industries that link with regional production, strategic industries such as ICT and industries with high value added products (e.g. the machine, electronic and automotive assembly industries).[2] It provides various types of investment incentives, which include an income tax holiday for a maximum of nine years, a special depreciation allowance of 40 per cent on the value of new or used tangible properties, and duty-free import of equipment and construction materials for production.

Indonesia launched Making Indonesia 4.0 in April 2018, a programme that encourages companies in seven priority industries to use Industry 4.0 technologies to improve efficiency and competitiveness and to reduce costs in the long term. These priority industries are food and beverages, garments, automotive, electronics, chemicals, pharmaceuticals and medical devices. The Government is also improving the country's business and investment environment (chapter 2), which would positively affect the attraction of FDI in Industry 4.0. These improvements include building nationwide digital infrastructure, upgrading training and skills development, establishing an innovation ecosystem, incentivizing technology investment, and optimizing regulation and policies. To help transform the manufacturing industry, the Government is developing 23 centres and technoparks for research and applied innovation involving partnerships with foreign companies and cooperation with other countries. For instance, the development of technoparks in Bandung (West Java) involves collaboration with the Korean Electronics and Telecommunication Research Institute, the Industrial Technology Research Institute (Taiwan Province of China) and Huawei (China).

In addition to developing technoparks, the Government is revitalizing the country's R&D facilities (Firdausy and Hidayat, 2021). In addition, the Government is planning 24 new R&D facilities, all of which will support the country's Industry 4.0 transformation. To assess progress on Industry 4.0 adoption and to measure the productivity and competitiveness of manufacturers, in February 2019 the Government launched the Industry 4.0 Readiness Index (INDI 4.0), a tool that supports

the Making Indonesia 4.0 programme. Also in 2019, the Government launched an annual INDI 4.0 award for companies. This is an initiative to encourage and recognize private sector efforts towards digital transformation. Since then, 18 companies have received the award.[3]

To attract FDI in Industry 4.0, Indonesia offers a package of incentives to investment in related areas. They include production of robot components for manufacturing of machinery and activities in the digital economy such as data processing and hosting. Key incentives provided are (i) exemption from corporate income tax for between 5 and 20 fiscal years, (ii) exemption from import duties and (iii) a tax reduction allowance up to 30 per cent of investment value.

The *Lao People's Democratic Republic* is implementing an industrial development plan and policies, contained in its Socioeconomic Development Strategy (2016–2025). A policy on Industry 4.0 is being planned. In the late 2000s, the Government established an e-government centre that is responsible for centralizing the government computer service, managing and developing the administration and service software, providing centralized government information and promoting e-government. The e-government development plan includes (i) a government intranet and ministry LAN telecommunication and internet infrastructure programme; (ii) a government data integration centre; (iii) digitalization of documents and supporting electronic signatures; (iv) promotion and implementation of various platforms – government-to-government (e.g. statistics, personnel, portal), government-to-business (e.g. licensing, investment, customs, trade, logistics), government-to-citizen (e.g. citizenship, education); and (v) human resource development (i.e. ICT training).

Several laws related to ICT and the digital economy have been adopted. They include a law on telecommunication in 2011, a law on cybercrime in 2015, a law on ICT and a decree on data centres in 2016, a law on electronic data protection in 2017 and a law on e-transactions in 2021.[4]

The Lao Digital Transformation Plan has been formulated. It includes (i) a programme for developing human resources in ICT; (ii) digital government services; (iii) a national network; (iv) a cloud platform and national data centres; (v) ICT-related policies, laws and regulations; (vi) development of a digital economy (e.g. e-commerce, e-tourism, e-agriculture); (vii) digital services for citizens (e.g. education, health care, a smart grid); (viii) development of a digital society (e.g. the IoT, innovation parks, green industry); and (ix) cybersecurity.

The Lao People's Democratic Republic provides tax exemption on profits for up to 15 years. The number of years depends on the type of activity or the type of investment zone where the project is located. Promoted areas include investments that use high-tech, scientific research and R&D and projects involving innovation.

Malaysia launched its National Policy on Industry 4.0, or Industry4WRD, in October 2018. Industry4WRD provides a comprehensive transformation agenda for manufacturing and related services. It encourages companies to adopt smart manufacturing technologies and promotes Malaysia as a destination for high-tech industries and a total solution provider for manufacturing and related services in the region (Wong et al., 2021). Under Industry4WRD, the Government through the Malaysia Development Bank established the RM2 billon Industry

Digitalization Transformation Fund, with a 2 per cent interest subsidy. The fund is intended to help accelerate the adoption of Industry 4.0 technologies. To further incentivize automation and modernization of the manufacturing industry, the Industry4WRD Intervention Fund provides to SMEs up to 70 per cent of the amount that is financed, guaranteed.

Prior to the Industry4WRD policy, the Eleventh Malaysia Plan (2016–2020) had encouraged investment in Industry 4.0-related technology in the manufacturing industry. The thrust is supported by two other efforts: the National IoT Strategic Road Map, launched in 2015, which is a guiding document for transforming Malaysia into a premier regional IoT hub, and the Big Data Analytics Initiative, launched in 2016, which is aimed at supporting digitalization.[5]

Since 2017, various programmes have been initiated to expand the country's digital economy. They include programmes to develop e-commerce and the launch of a digital free trade zone to facilitate cross-border trade and enable local businesses to export goods with priority given for e-commerce. In October 2020, the Government launched the Malaysia Cybersecurity Strategy 2020–2024 to step up national cybersecurity preparedness, advance data security and attract MNEs to invest in data centres and regional headquarters.[6] The Digital Economy Blueprint, launched in February 2021, aims to upgrade digital infrastructure and to encourage industrial players or companies to take a more significant role in supporting the growth of the digital economy in the country.

The Government has implemented various measures to attract investment in automation, ICT equipment and software, and activities related to Industry 4.0:

(i) Incentives for automation of production of robots, factory automation equipment, and specialized machinery and equipment. Approved projects get pioneer status, with a tax exemption of up to 100 per cent of statutory income for up to 10 years or an investment tax allowance of up to 100 per cent on qualifying capital expenditure incurred within five years. Qualified investors can also apply for a soft loan scheme for automation and modernization purposes such as to (i) modernize and automate a manufacturing process, (ii) to upgrade production capability and capacity, (iii) minimize dependence on labour-intensive activities and foreign labour, (iv) diversify into higher value added activities and (v) rationalize and streamline operations, including through mergers and acquisitions. In addition, an automation capital allowance is provided to encourage adoption of automation in manufacturing. It also covers up to 100 per cent of expenditures on automation equipment.

(ii) Capital allowances for ICT equipment and software. Investors can claim capital expenses for qualifying expenditures on (i) purchase of ICT equipment and computer software packages and (ii) development of customized software, comprising fees for consultation, licensing and incidentals related to software development. Capital allowance rates are 20 per cent initially and then annually.

(iii) The Domestic Investment Strategic Fund Industry*4WRD* provides matching grant for local companies seeking investment in upgrading or enhancing technological capabilities to be more competitive internationally, move up the company's value chain and enable the company to be active participants in targeted industries such as those involved with

high value added, high-technology, knowledge-intensive and innovation-based activities. The grant includes adoption of key technologies such as big data analytics, autonomous robots, IoT, cybersecurity, cloud computing, additive manufacturing, and AI.

(iv) The Automation Capital Allowance incentive is to encourage manufacturing companies to engage in innovative and productive activities, quick adoption of automation specifically for labour-intensive industries and automation initiatives. Qualified investors receive an automation capital allowance of 200 per cent on the first RM4 million (labour-intensive industries) or RM2 million (other industries) in expenditure incurred within eight years of assessment, from 2015 to 2023.

Companies investing in digital businesses can also receive support (e.g. information, advice, investment application service and facilitation in setting up operation) from dedicated institutions. They include the Malaysia Investment Development Authority (MIDA), the Malaysia Digital Economy Corporation (MDEC), Malaysian Global Innovation & Creativity Centre, Malaysian Technology Development Corporation (MTDC), the Malaysian Industry-Government Group for High Technology, and Malaysian Science and Technology.

Myanmar's national economic development policy includes digitalization. The Government is reviewing laws and regulations needed to support Industry 4.0 transformation. Application of industrial automation technology is limited. Most production is based on manual labour, and few factories are automated. Through regional cooperation, though, Myanmar could leapfrog to automation, shortening the learning curve by learning from experiences of other Member States.

The country faces serious challenges in achieving Industry 4.0 development. Much of the infrastructure either needs upgrading or improvement or requires new development. Without that lift, progress in digitalization and digital connectivity will be constrained, which in turn will limit application of Industry 4.0 technologies. The development of the country's telecommunication industry has underscored that leapfrogging is possible. Four telecommunication companies operate in Myanmar, providing 2G to 4G technology. Two operators are foreign companies (i.e. Ooredoo (Qatar) and Telenor (Norway)). Although few in number, foreign companies are investing in the development of data centres (e.g. GTMH (Hong Kong, China) and True IDC (Thailand)).

The Government promotes investment that supports sustainable economic growth, particularly in 20 sectors, that include information technology services and telecommunication businesses. Various types of investment measures have been adopted under the Myanmar Investment Law, enacted in 2016. They include a simplified investment application process, tax exemptions, investment guarantee protection and land lease rights.[7]

The *Philippines* has adopted the Philippine Development Plan (PDP 2017–2022), which recognizes that expanding economic opportunities will be best achieved through accessing new technology and innovation, building innovative talent and encouraging entrepreneurship that uses technology-enabled business models to leverage opportunities and the growth of budding small-scale enterprises. This vision is strengthened by the Philippine Innovation Act or Republic Act No. 11293, which mandates all government agencies to generate and scale

up actions at all levels and in all areas of education, training and R&D to promote innovation and the internationalization activities of micro, small and medium enterprises as drivers of sustainable and inclusive growth.

To realize this vision, the Department of Trade and Industry (DTI) is implementing the Inclusive Innovation Industrial Strategy (referred to as i3S), the country's new innovation-centred and science- and technology-based industrial policy in collaboration with industry and academia. It aims to grow globally competitive and innovative industries and deepen their participation in global and regional value chains. The new industrial policy has six strategic actions: (1) embrace Industry 4.0, (2) integrate production systems, (3) build the innovation and entrepreneurship ecosystem, (4) upskill and reskill the workforce, (5) improve the ease of doing business, and (6) develop innovative SMEs and start-ups.

The strategy highlights the need to embrace new and advanced technologies arising from Industry 4.0 that would enhance productivity, develop new industries, build industrial competitiveness and generate linkages in production systems, all towards the goal of realizing inclusive, sustainable and resilient industrial development. To build the Industry 4.0 ecosystem, the Government is spearheading implementation of the following programmes:

(i) Industry 4.0 Readiness Assessments. The DTI is partnering with Siemens (Germany) and the World Economic Forum (WEF) to scale up adoption of the Smart Industry Readiness Index (SIRI) among Philippine manufacturing firms, especially in the automotive, electronics, aerospace, chemicals, food manufacturing and construction materials industries.

(ii) Industry 4.0 Road Maps. After the readiness assessments, the DTI helps manufacturers develop their own Industry 4.0 company road map to set the pace of their adoption and outline their steps for future targeted action.

(iii) Industry 4.0 Pilot Factory. The DTI will establish an Industry 4.0 Pilot Factory to host demonstrations, simulations of technologies outlined in companies' Industry 4.0 road maps and case applications of Industry 4.0 technologies that enterprises (especially MSMEs) can access to facilitate adoption. This will be supported by an Industry 4.0 SME Academy to boost manufacturing innovation and develop the human resource capabilities of MSMEs to ensure their resilience and competitiveness.

(iv) Industry 4.0 Skills Development. The DTI, together with the Technical Education and Skills Development Authority, partnered with SkillsFuture Singapore to enhance the country's human capital by reskilling and upskilling the workforce. Among the priority industries for the development of skills frameworks are construction, creatives, food and agriculture, health and wellness, information technology (IT) business process management, logistics, manufacturing and tourism.

(v) Strategic MSMLE and Startup (SMART) Link. The programme is a platform to connect technology start-ups that can provide digital solutions for traditional micro, small, medium and even large enterprises through online meetings, direct referrals or endorsements.

The country's National AI Road Map positions the Philippines as a regional hub for big data processing and analytics, building on its large footprint in the global IT and business

process management industries. One of the major recommendations of the Road Map is the establishment of the National Center for AI Research, which will be a regional AI centre of excellence where multinational companies and MSMEs, in the Philippines and abroad, can explore AI R&D projects with the Philippine government and its researchers, and through their linkages with universities and research institutes. The Department of Science and Technology has inaugurated the country's Advanced Manufacturing Center to advance additive manufacturing in research, industry application and training.

The Regional Inclusive Innovation Centers are at the heart of the transformation. They promote inclusive growth and development in the country. They bridge the gaps and forge linkages among innovators, entrepreneurs and enablers in the country's regional innovation and entrepreneurship ecosystems to support enterprises, especially MSMEs, in innovating products, processes and business models, and to address market gaps and societal needs.

Republic Act No. 11534 – the Corporate Recovery and Tax Incentives for Enterprises (CREATE) Act – enhanced the country's attractiveness for investment projects and rationalized the investment incentive system to be more innovation-driven. Under the Act, the highest level of incentives (up to 17 years of combined income tax holiday as well as special corporate income tax and enhanced deductions) will be provided to five kinds of economic activities: (i) R&D with significant value added, higher productivity, breakthroughs in science and health and high-paying jobs; (ii) generation of knowledge and intellectual property registered or licensed in the country; (iii) commercialization of patents, industrial designs, copyrights and utility models; (iv) highly technical manufacturing (using AI, automation, robotics and digital technologies); and (v) activities critical to structural transformation of the economy.

Singapore provides policy, specific facilities and institutional support to encourage or accelerate Industry 4.0 transformation, including building a vibrant research and innovation ecosystem and establishing purpose-designed industrial facilities (box 4.3). In 2017, Singapore's Economic Development Board (EDB) launched the SIRI as a common framework for understanding Industry 4.0 and evaluating companies' readiness levels. A prioritization matrix was also launched to help companies develop and execute Industry 4.0 transformation plans. Enterprise Singapore and the Singapore Standards Council developed a standard tool for mapping relevant national and global standards in areas such as operations, supply, automation and talent readiness relative to the SIRI. The EDB has also launched an industry network scheme to help companies accelerate the implementation of industry transformation programmes by linking technology, financing, talent development and training partners.

Transformation to Industry 4.0 is also supported through education and training, by empowering the local talent pool through development of appropriate skills. SkillsFuture Singapore provides guiding frameworks and plays a role in workforce transformation towards Industry 4.0. Some programmes include reskilling and upskilling of workers in targeted industries. Academic-industrial collaboration is encouraged, with funding for corporate labs to tackle current Industry 4.0 issues such as cybersecurity, cyberphysical systems and smart industrial production. Local universities have partnered with corporations such as Rolls-Royce (United Kingdom), HP (United States), Applied Materials (United States), ST Engineering and SingTel (both Singapore).

Box 4.3. Singapore: Institutional support for Industry 4.0 transformation

Singapore is strengthening institutional support for Industry 4.0 transformation, including by establishing international cooperation through government-to-government initiatives. For example, the Government has signed three memorandums of understanding with Germany. One facilitates accelerator programmes, to support high-potential German start-ups in entering the Southeast Asian market. Singapore has also concluded negotiations on two digital economy agreements – the Digital Economy Partnership Agreement with Chile and New Zealand and the the Singapore–Australia Digital Economy Agreement. These agreements build on Singapore's network of free trade agreements and other digital collaborations.

Singapore's Institutes of Higher Learning are also collaborating with industry leaders to equip workers with the appropriate practical skills. In October 2020, the Agency for Science, Technology and Research (A*STAR), the EDB and Enterprise Singapore partnered with Nanyang Technological University and SkillsFuture Singapore to set up the Advanced Manufacturing Training Academy in the Jurong Innovation District (JID). The Academy's programme office will work with the Institutes of Higher Learning and training providers to develop effective educational programmes to identify emerging industry needs for advanced manufacturing and help workers adapt accordingly.

Purpose-built infrastructure

Singapore has invested in the JID, a premier advanced manufacturing hub. Start-ups and incubators are housed in close proximity to businesses and academia, fostering strong collaborations and accelerating the commercialization of new technologies. This ecosystem provides a one-stop location for manufacturing companies to prototype and test various Industry 4.0 solutions and to kickstart production and distribution. The growing JID ecosystem attracted a cluster of technology companies in 2020 (box figure 4.3.1). Within the R&D cluster are A*STAR's two model factories: the Advanced Remanufacturing and Technology Center (ARTC) and the Singapore Institute of Manufacturing Technology. Local companies can use these model factories to co-develop and test new technologies in a real-life production environment. The A*STAR Model Factory Initiative has supported more than 100 enterprises in improving business productivity and efficiency (A*STAR, 2020).

Advanced Remanufacturing Technology Centre

Launched in 2015, the ARTC is built on strong public-private partnerships for test-bedding and developing advanced manufacturing processes. Led by A*STAR, in partnership with Nanyang Technological University, the ARTC has more than 80 members, ranging from global manufacturing industry leaders (e.g. Rolls-Royce, Nestlé, Shell and Siemens) to technology and service providers (e.g. Microsoft, ABB, Emerson and Bosch Rexroth) and SMEs (e.g. Abrasive Engineering, PBA Systems and DataVLT). The ARTC offers technologies and expertise in three solution areas that form the essence of smart manufacturing: secure connectivity and intelligent systems, virtual manufacturing and end-to-end solutions.

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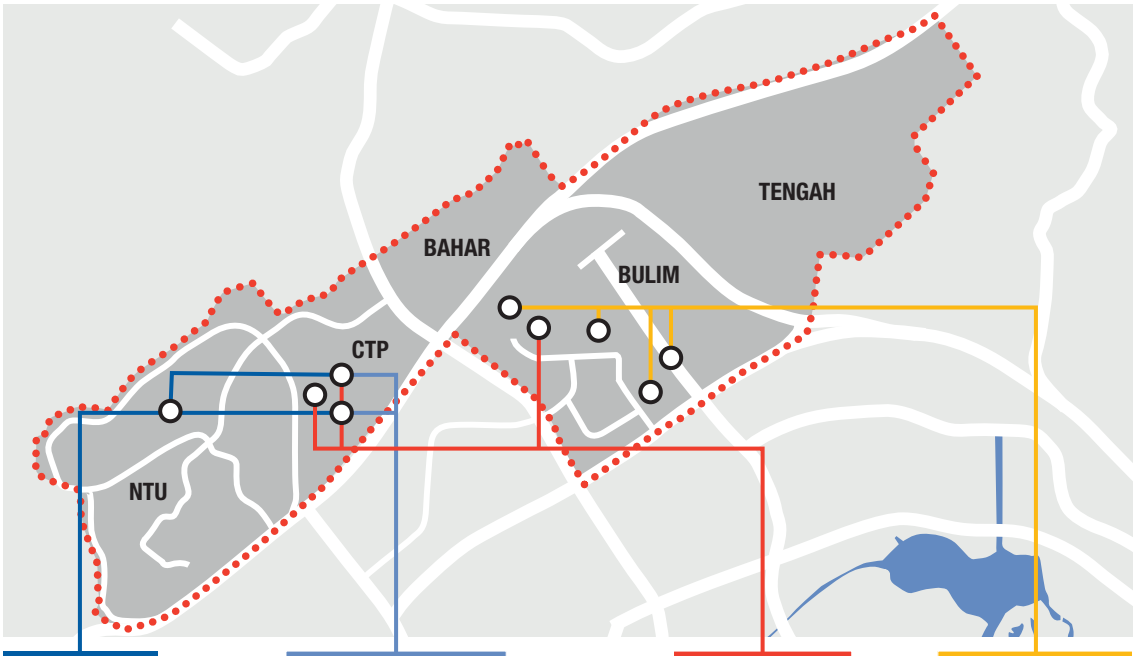
Box 4.3. Singapore: Institutional support for Industry 4.0 transformation (Continued)

Box figure 4.3.1. Jurong Innovation Park



Talent & Training

- Nanyang Technological University
- Bosch Rexroth Regional Training Centre
- Advanced Manufacturing Training Academy[a]

Research & Development

- A*STAR's Advanced Remanufacturing and Technology Centre
- A*STAR's Singapore Institute of Manufacturing Technology
- A*STAR's National Metrology Centre
- Digital Capability Centre Singapore

Technoloy Providers

- Siemens
- Sodick
- ISDN
- Konica Minolta[a]
- Fanuc[a]
- Makino[a]
- DMG MORI[a]

Factories of the future

- Angel Playing cards
- Hyundai Motor Group[a]
- YCH Group
- Shimano

Source: JTC (2021).
[a] New entrants.

5G innovation ecosystem

The Government has put in place a plethora of measures to support Singapore's vision of becoming a global leader in 5G innovation and applications, including the goal of attaining 5G coverage for half of the country by the end of 2022 and for the entire nation by 2025. These include an investment of S$40 million by the Infocomm Media Development Authority and the National Research Foundation into building an open and inclusive 5G ecosystem. In addition, the Authority has partnered with a diverse range of industry leaders to use 5G digital infrastructure in developing Industry 4.0 solutions. For example, in September 2020 it launched the Living Lab@PIXEL 5G test bed to support businesses, including SMEs, in experimenting with 5G technology. The test bed has already garnered substantial interest, with many companies using the opportunity to incorporate 5G into their own Industry 4.0 solutions.

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Box 4.3. Singapore: Institutional support for Industry 4.0 transformation (Concluded)

Public-private partnership for knowledge solutions

Throughout ASEAN, companies tend to initiate collaboration within their own organizations (McKinsey, 2018). The Singapore Government has accelerated Industry 4.0 technology adoption by catalysing the organization of similar companies into industrial clusters. For example, a $34 million consortium agreement – the Pharma Innovation Programme Singapore – has helped to strengthen the pharmaceutical manufacturing industry in Singapore with more sustainable processes and quicker production of active ingredients. This programme is the result of an agreement signed between A*STAR, local universities and three leading pharmaceutical companies (GlaxoSmithKline, MSD International and Pfizer) in 2018.

Collaboration with technology providers

Besides manufacturers, the Singapore Government has also collaborated with technology providers to develop Industry 4.0 innovations. In November 2017, the EDB established the SIRI in partnership with TÜV SÜD, a global certification and training provider, and validated it with a network of leading academics and industry leaders. The index is the world's first Industry 4.0 tool developed to support manufacturers in their transformation journeys. With two matrices – the Assessment Matrix and the Prioritization Matrix – acting as benchmarks for self-evaluation, companies are guided through the four main steps of their Industry 4.0 transformation journey – to learn, evaluate, design and deliver impact (appendix B). The SIRI is used to assess more than 350 Singapore-based firms from more than 15 countries. The EDB plans to conduct 500–750 more assessments by the end of 2021.

Source: Tan et al. (2021).

The Government has also established dedicated institutions and hubs to support innovation and Industry 4.0 transformation. The JTC Launchpad in the JID is an advanced manufacturing hub close to knowledge-based companies, institutions of higher learning, dedicated public institutions (e.g. A*STAR and the Institute of Manufacturing Technology) and research organizations associated with innovation. The hub consists of diverse start-ups, incubators, venture capitalists and other technology ecosystem partners. Some MNEs operating in the hub include Bosch Rexroth (Germany), Flowserve (United States), Hyundai Motor Group (Republic of Korea) and Siemens (Germany). In late 2020, DMG Mori (Germany) established a facility in the hub to provide technology development and technical support for machine tools, systems and software, and additive manufacturing equipment. Makino (Japan) is opening an Additive Manufacturing Centre of Excellence, offering prototyping and consultancy services, and conducting training to support adoption of additive manufacturing by industry players. Konica Minolta (Japan) announced plans to set up a regional headquarters to showcase innovative technology by 2023, and Fanuc (Japan) announced plans to open a centre providing computer numerical control and robotics equipment maintenance and servicing.[8]

The EDB lists 17 priority business activities and industries that the Government aims to attract (e.g. advanced manufacturing, innovation, ICT). It offers investors corporate tax exemption under the Pioneer Certificate or a concessionary tax rate of 5 or 10 per cent on income derived

from qualifying activities for five years under the Development and Expansion Certificate. Extension of the incentives may be considered, subject to the company's commitment to undertake further expansion.[9] Other incentives and schemes the Government offers to grow targeted industries include (i) the Tech@SG Programme, to help fast-growing companies capture business opportunities in Singapore and in the region, and to facilitate the entry of global technology talent for eligible companies; (ii) the Tech.Pass, which provides support to established technology entrepreneurs or technical experts to come to Singapore to develop frontier and disruptive innovations; (iii) the Research Incentive Scheme, which encourages development of R&D capabilities and technologies; (iv) training grants to support human resources development in the application of new technologies, industrial skills and professional know-how; (v) the Intellectual Property Development Incentive, to encourage the use and commercialization of intellectual property rights arising from R&D activities; and (vi) the Land Intensification Allowance, to promote intensification of industrial land use for land-efficient and higher value added activities.

Thailand embarked on the Thailand 4.0 reform in 2016. This major reform process identifies science, technology, innovation, value addition and R&D as major areas that are important to drive economic growth. The Government passed three acts in 2019 that relate to digitalization (i.e. the Electronic Transactions Act, the Personal Data Protection Act and the Cybersecurity Act). These acts govern the country's regulatory environment, promoting reliability in electronic transactions while protecting personal data.

Other initiatives to support Industry 4.0 transformation have also been adopted. New industries promoted under Thailand 4.0 include robotics and automation, aviation and logistics, biofuels and biochemicals, smart electronics, next-generation automotive, agriculture and biotechnology, and industries related to a medical hub.

In 2017 Thailand launched the Eastern Economic Corridor, which houses Digital Park Thailand, to lead in the country's digital transformation efforts. Digital Park Thailand aims to be a digital hub and offers cutting-edge digital infrastructure such as ultra-high-speed broadband and data centres. New industries are being promoted in the Eastern Economic Corridor by providing tax incentives and collaboration with universities and public research institutes.

The Thailand National Innovation Agency has been promoting innovation districts since 2015. It has started to develop 10 in Bangkok and the surrounding provinces, working with enterprises, universities, hospitals, start-ups, local experts and residents. The model is area-based innovation, which builds an innovation ecosystem and creates a regional cluster. For example, Bangkok has a distributed network of seven innovation districts: the Bangkok CyberTech District, the Yothi Medical Innovation District, the Kluaynamthai Innovative Industries District, the Pathumwan Innovation District, the Khlong San Innovation District, the Rattanakosin Innovation District and the Latkabung Innovation District.

The Board of Investment (BOI) of Thailand has targeted 12 sectors for investment, which include smart electronics, robotics and the digital economy. Qualified investors in these sectors are offered (i) corporate income tax exemption for up to 13 years (for core technologies and

R&D projects) and a tax holiday for up to 15 years for new technologies as well as a high-impact investment matching grant for R&D, training and innovation; (ii) exemption from import duties on machinery and on raw materials imported for use in production for export and for R&D; (iii) a 50 per cent reduction of corporate income tax within 10 years; (iv) an investment tax allowance of up to 70 per cent of the invested capital on net profit derived within 10 years; (v) 100 per cent foreign ownership (no local requirements, no export requirements, no restriction on foreign currency) and (vi) land ownership rights.[10] It also provides information to investors on laboratories in universities and public research institutes that conduct research on Industry 4.0 technologies.

The Government has established the Digital Economy Promotion Agency (DEPA) to encourage investment and development of digital industries and enterprises in the country. The DEPA and the BOI actively promote investment in digitalization. Like the other Member States, Thailand is also promoting technology start-ups in manufacturing and services.

Viet Nam has a long-term plan to become a digital country, and the Government has adopted resolutions on digital transformation. The Government aims to improve the country's competitiveness and encourage innovation by capitalizing on Industry 4.0 opportunities, including enhancing cooperation with foreign corporations in accessing and adopting Industry 4.0 technology. Increasing numbers of Industry 4.0 solution providers are establishing a presence in the country, which will help provide manufacturers with easier access to technology solutions. Some of these solution providers include ABB (Switzerland), IBM (United States), HPE (United States), Schneider (France) and Siemen (Germany).

In September 2019, the Government approved Resolution No. 52-NQ/TW, which provides a comprehensive outline of policies and targets for Industry 4.0 development. In the same year, the new law on cybersecurity came into effect, which made it mandatory for international technology companies to establish a physical presence and store data locally in the country.[11]

In June 2020, the Government approved the National Digital Transformation Programme by 2025. The programme aims to create a digital government, digital economy and digital society while establishing globally competitive digital businesses. The programme strengthens the country's efforts to digitalize through a number of channels:

(i) It builds on past efforts to turn Viet Nam into a digital society over the next decade, notably by establishing national databases, making government services available online and continuing to develop and increase access to 4G and 5G networks across the country.

(ii) It promotes the development and widespread use of e-commerce platforms in enterprises and in the community.

(iii) It provides incentives and support for start-up development and encourages large companies to make use of new technologies and commercial activities.

(iv) It shifts the economy from the assembly and processing of high-tech goods to manufacturing in line with a Made in Vietnam strategy launched in May 2019 to foster 100,000 tech firms and make Viet Nam a technological powerhouse.[12]

On 17 July 2020, the National Assembly of Viet Nam passed a new law on investment (Law No. 61/2020/QH14), which replaces Law No. 67/2014/QH13 (passed in 2014). The new law came into effect on 1 January 2021. It expands the list of investment targets to include data centre services and digital payment services in 227 business areas. They include e-commerce, telecommunication services, digital signature authentication services, trading of games on telecommunication networks and the internet, mobile and internet content services, electronic identification and authentication, and cybersecurity products and services.[13] Article 16 of the new law covers (i) manufacture of products derived from scientific and technological results, (ii) manufacture of products supporting industrial development, (iii) higher education, (iv) production of medical equipment and (v) production of goods and provision of services creating high value or enabling participation in industry value chains.[14]

Investment incentives are granted to approved foreign investments in promoted sectors. They include corporate income tax exemption (up to 13 years) or preferential tax rate (10 per cent) up to 15 years, deductible expenses and exemption from import duties for imported machines and equipment.[15]

In addition, various resolutions, decisions and directives to promote Industry 4.0 transformation were adopted, with some specific targets to be realized by a certain time frame (box 4.4). Interest in Industry 4.0 technologies by manufacturers is growing. Along with other efforts, the Government is taking steps to raise awareness and promote Industry 4.0 adoption. For instance, an Industry 4.0 Summit with the presence of ministers and the prime minister is scheduled for July 2021 in Hanoi.

Box 4.4. Viet Nam: Resolutions, decisions and directives on Industry 4.0

The Government of Viet Nam has adopted specific resolutions, decisions and directives to support Industry 4.0 transformation in the country. Some of these measures include targets for strengthening key areas of the digital ecosystem, such as development of the country's digital infrastructure and skills upgrading (box table 4.4.1).

Box table 4.4.1. Viet Nam: Resolutions and legal instruments on Industry 4.0

Document	Issue date	Objective	Selected targets
Resolution No. 52-NQ/TW, Politburo	27 September 2019	Outline strategies and provide policies to proactively embrace Industry 4.0 transformation	• Require ministries and local governments to adopt digital technologies • Foster digital transformation across socioeconomic sectors • Digital skills upgrading through education, training and key research programmes • Specific targets: (i) 100 per cent broadband internet coverage for all communes by 2025 (ii) 5G network coverage nationwide

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Box 4.4. Viet Nam: Resolutions, decisions and directives on Industry 4.0 (Concluded)

Box table 4.4.1. Viet Nam: Resolutions and legal instruments on Industry 4.0 (Concluded)

Document	Issue date	Objective	Selected targets
Decision 2289/QD-TTg, Prime Minister	31 December 2020	Promulgate national strategy on Industry 4.0 to 2030	• Set strategic direction to adopt Industry 4.0 transformation • Assign Ministry of Planning and Investment, Ministry of Information and Communication, and Ministry of Science and Technology as the coordinators for implementing the national strategy on Industry 4.0 • Specific target: Digital economy to account for 30 per cent of the country's GDP by 2030
Directive No. 16/CT-TTg, Prime Minister	4 May 2017	Strengthen capabilities to embrace Industry 4.0 technologies	• Promote investment in strategic digital infrastructure, application and human resources development for ICT, and network security • Improve business environment, including developing innovative start-up ecosystems • Raise levels of national awareness on Industry 4.0 transformation
Resolution 50/NQ-CP, Government	17 April 2020	Promulgate action plan to implement the Politburo's 52-NQ/TW Resolution	• Set out key approaches and measures to promote Industry 4.0, with a special focus on nationwide digital transformation, promote investment in key digital infrastructure, human resource development and strategic technologies
Decision No. 2117/QD-TTg, Prime Minister	27 September 2019	Promulgate prioritized Industry 4.0 technologies for investment	Priority digital technologies include • AI, IoT, big data, blockchain, cloud, quantum computing, virtual reality, augmented reality • Engineering (robot, 3D printing, nanotech, new materials, micro/nanosatellites, photonics and light technologies) • Biotechnologies (synthetic biology, neuro-technologies, stem cells, bioinformatics, biochips and sensors, regenerative medicine, tissue engineering, sequencing technologies)
Directive No. 01/CT-TTg, Prime Minister	14 January 2020	Promote the development of digital businesses in Viet Nam	• Increase the number of digital businesses to 70,000 by 2025 and 100,000 by 2030 • Expand the workforce of digital businesses to 1.2 million by 2025 and 1.5 million by 2030 • Digital businesses to account for 10 per cent and 20 per cent of GDP by 2025 and 2030, respectively • Rank in the top 70 in the world for technology and innovation by 2025 and the top 50 by 2030

Source: *ASEAN Investment Report 2020–2021* research, based on Vu (2021), country information and media.
Note: AI = artificial intelligence, GDP = gross domestic product, ICT = information and communication technology, IoT = internet of things.

4.3.2. Regional cooperation and agreements

ASEAN Member States have been cooperating on ICT and digital development for more than two decades. Regional cooperation dates to the implementation of the e-ASEAN Framework Agreement, signed on 24 November 2000. It outlined regional cooperation in ICT, with the objective of reducing the digital divide, promoting cooperation between the public and private sectors, and promoting liberalization of trade and investment in related goods and services.

Regional cooperation in recent years has focused on digitalization and Industry 4.0 development (table 4.3). For instance, the ASEAN Economic Blueprint 2025 lays out major measures and work plans to achieve the ASEAN Economic Community (AEC) by 2025, a fully integrated region with free flows of investment, capital, goods and services, and enhanced connectivity. Work activities related to Industry 4.0 transformation featured prominently in the Blueprint. It aims to strengthen industrial cooperation and improve efficiency in manufacturing by using technologies. Some of the measures include promoting cross-border e-commerce, cooperating on cybersecurity and data privacy, building digital infrastructure connectivity and developing and connecting smart cities.

Table 4.3. ASEAN cooperation on ICT, digitalization and Industry 4.0 (Selected cases)

Document/event	Date signed	Objective
ASEAN Ministerial Conference on Cybersecurity	11 October 2016 (first conference)	Cybersecurity cooperation
ASEAN Economic Community (AEC) Blueprint 2025	November 2016	The AEC Blueprint 2025 lays out a state of regional integration that supports free flows of trade, investment, services and capital. The Blueprint guides the implementation of work plans and programmes to realize the AEC. Related Industry 4.0 objectives and measures in the Blueprint include these two: • propelling ASEAN towards a digitally enabled economy that is secure, sustainable and transformative, and further leveraging ICT to enable an innovative, inclusive and integrated ASEAN • strengthening cooperation on e-commerce and facilitating cross-border e-commerce transactions in ASEAN
Work Programme on E-commerce (2017–2025)	November 2017	The Work Programme lays out steps to implement the e-commerce agreement with specific actions and timelines. Key areas of work include these five: • *Infrastructure* development (e.g. mobile roaming and broadband accessibility; grow e-marketplace and e-commerce platforms) • *Consumer protection* (e.g. code of conduct for online business; consumer rights awareness, availability of alternative dispute resolution) • Security of electronic transactions (e.g. personal data/privacy protection; international cooperation with cybersecurity agencies; secure authentication mechanisms) • Logistics (logistics services to facilitate e-commerce) • Updated e-commerce legal framework

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Table 4.3. ASEAN cooperation on ICT, digitalization and Industry 4.0 (Selected cases) (Concluded)

Document/event	Date signed	Objective
ASEAN Agreement on Electronic Commerce	November 2018	The Agreement contains provisions that facilitate cross-border e-commerce transactions by creating an environment of trust and confidence. It deepens regional cooperation to develop and intensify the use of e-commerce.
ASEAN Smart Cities Network	November 2018	The Network facilitates cooperation on developing smart cities with private sector participation. It currently involves 26 ASEAN cities that are applying smart technologies (e.g. the IoT and big data) to improve efficiency and support rapid urbanization.
ASEAN Declaration on Industrial Transformation to Industry 4.0	November 2019	The Declaration aims to advance regional cooperation and adoption of Industry 4.0 transformation. Major elements include these three: • Facilitate ASEAN's industrial transformation to Industry 4.0 to achieve sustainable development • Foster industrial collaboration among Member States • Create a prosperous and equitable ASEAN community by embracing innovation and digital technologies in Industry 4.0 to accelerate economic growth and social advancement
ASEAN Digital Integration Framework Action Plan 2019–2025	November 2019	The Action Plan aims to help overcome barriers of digital integration, such as in (i) digital connectivity and affordable access, (ii) the financial ecosystem, (iii) commerce and trade, (iv) workforce transformation and (v) the business ecosystem.
ASEAN Declaration on Human Resources Development for the Changing World of Work	June 2020	The Declaration addresses preparing ASEAN's human resources with competencies for Industry 4.0 as well as the potentially negative impact of disruptive technologies.
37th ASEAN Summit	November 2020	The Leaders provided new mandates related to regional digital development, which include these five: • Best practices for 5G ecosystem development • Lowering international mobile roaming rates • Establishing an ASEAN Network of Innovation Centres • Establishing an ASEAN Cybersecurity Resilience and Information Sharing Platform for sharing threat intelligence and best practices related to cybersecurity • Finalizing a memorandum of understanding to operationalize information sharing
ASEAN Comprehensive Recovery Framework	November 2020	The Framework provides a consolidated exit strategy from the pandemic (recovery and aftermath actions) and for building a resilient region through five strategic thrusts, with emphasis on adopting Industry 4.0 technologies. The five thrusts are (i) enhancing health systems, (ii) strengthening human security, (iii) maximizing the potential of the intra-ASEAN market and broader economic integration, (iv) accelerating inclusive digital transformation, and (v) advancing towards a more sustainable and resilient future.
ASEAN Digital Masterplan 2025	January 2021	The Masterplan provides a guide towards achieving a digital community and economic bloc, powered by secure and transformative digital services, technologies and ecosystem. Major activities include these four: • Promoting investment in new technologies • Removing regulatory barriers to digital market operations • Supporting social measures for digital inclusion and digital skills • Ensuring digital safety of the end users
ASEAN Ministers on Digital Cooperation Inaugural Meeting	January 2021	The ministers agreed to deepen and accelerate regional Industry 4.0 transformation through cooperation programmes, regional policies (including on cybersecurity) and to pursue collaborative activities on Industry 4.0 with ASEAN dialogue partners (United States, European Union, Japan, Republic of Korea, China).

Source: ASEAN Secretariat.

Cooperation on Industry 4.0 has important implications for digital development, improving the region's investment environment and providing opportunities for investment and private participation. Such cooperation contributes in the following ways:

(i) Fostering regional digital connectivity and developing a regional digital market.

(ii) Sharing experiences and best practices among Member States, with implications for strengthening the national and regional ecosystems and connectivity, such as through the ASEAN smart city networks and implementing or setting standards and guidelines.

(iii) Narrowing the development gap for some Member States, such as through cooperation on cybersecurity matters and regional initiatives promoting e-commerce development under the ASEAN Agreement on E-commerce. Regional cooperation also facilitates convergence and provides opportunities for some Member States to leapfrog in their digital development path or in technological adoption.

(iv) In response to the economic impact of the pandemic, in November 2020 the ASEAN Member States adopted the ASEAN Comprehensive Recovery Framework, aiming for sustainable recovery in the region. The framework consists of five strategic thrusts and an implementation plan. Two of the strategic thrusts directly relate to promoting the adoption and development of Industry 4.0 technologies. They are strategy 4, accelerating inclusive digital transformation, and strategy 5, advancing towards sustainable and resilient future (e.g. promoting high-value industries).

(v) Harnessing the benefits of Industry 4.0 technologies to build a more resilient and efficient industrial and business environment, guided by the ASEAN Declaration on Industrial Transformation to Industry 4.0 and the ASEAN Digital Master Plan 2025. Improving the business and investment environment can lead to lower transaction costs and stronger business ecosystems. In addition to strategies 4 and 5 of the ASEAN Comprehensive Recovery Framework, strategy 1 (enhancing health systems) and strategy 3 (maximizing the potential of the intra-ASEAN market and broader economic integration) will provide investment opportunities and improve the competitiveness of the region's digital and investment ecosystems.

(vi) Increasing opportunities for private investment in digital development, especially in Industry 4.0 activities. This includes adoption, supply, development and upgrading of factories and smart cities with Industry 4.0 technologies.

In particular, regional cooperation can provide opportunities for foreign technology solution providers, manufacturers and other MNEs to participate in the region's digital market development and Industry 4.0 transformation. Other specific aspects of regional implications for digital development and Industry 4.0 include the following:

(a) Regional digital market opportunities

Regional cooperation is important for digital market growth and for companies to benefit from economies of scale and from the expanding e-commerce market. This includes regional efforts in promoting the free flow of ICT products, services and investments; facilitating cross-border e-commerce; harmonizing digital regulations; and facilitating cross-border data flows.[16]

The digital economy in ASEAN is growing rapidly. In 2020, there were 400 million digital service users in the six largest ASEAN economies, accounting for 70 per cent of the population in these countries. The region's digital market is projected to grow nine-fold, from just $32 billion in 2015 to more than $300 billion by 2025 (Google, Temasek and Bain, 2020). Major reasons for that projection are the rapid and robust growth in e-commerce, high mobile and internet penetration rates, and favourable support by Member States for digitalization. The numbers of mobile connections and internet users in all ASEAN countries have grown rapidly between 2011 and 2020 (table 4.4), and this growth trajectory is expected to continue. The pandemic has also led to more usage of digital services and greater access to e-commerce, online media, electronic payment systems and food delivery services. Market conditions, regional cooperation and national support for digital market development offers opportunities for investment by start-ups and venture capital firms.

Table 4.4. Digital connectivity in ASEAN

	Mobile connections		Internet penetration	
ASEAN country	Penetration, 2020 (%)	Growth 2011–2020 (%)	Penetration, 2020 (%)	Growth 2011–2020 (%)
Brunei Darussalam	130	30	95	30
Cambodia	128	108	58	2 842
Indonesia	124	61	64	343
Lao People's Democratic Republic	79	49	43	488
Malaysia	127	26	83	76
Myanmar	126	7 923	41	19 900
Philippines	159	97	67	146
Singapore	147	17	88	41
Thailand	134	30	75	184
Viet Nam	150	12	70	133

Source: We are Social Inc.

(b) Cybersecurity and data protection

Regulatory bottlenecks and a lack of trust in electronic transactions can hold back the growth of digital development. ASEAN Member States are cooperating on cybersecurity and data protection.[17] Regional cooperation on cybersecurity has intensified with the implementation of the E-Commerce Work Programme (2017–2025), which includes work on a regional code of conduct for online business and consumer rights awareness, dispute resolution and the security of electronic transactions (e.g. personal data protection and privacy, international cooperation with cybersecurity agencies and authentication mechanisms). Under the AEC Blueprint and the

accompanying 2025 Strategic Plan of Action, Member States are addressing the development of regional data protection principles, network security best practices and resilience practices for critical information infrastructure. ASEAN's work on ensuring cybersecurity, data protection and end-user privacy is geared towards building trust and confidence in the usage and application of technology across the region. Development in this area could have implications for investment and investors operating in ASEAN.

(c) Smart Cities Network

The ongoing implementation of the ASEAN Smart Cities Network can help strengthen the digital ecosystem and the investment environment. In 2018, the ASEAN Leaders established the ASEAN Smart Cities Network, a collaborative platform involving 26 selected smart cities across the region.[18] These cities are using technology to build digitally connected and efficient cities, interconnect among themselves, and support Industry 4.0 transformation. The Network aims to improve urbanization and generate economic opportunities by applying smart technologies such as the IoT, AI and sensors. The establishment of smart cities in the region provided opportunities for private investment, including by MNEs in Industry 4.0 technologies (table 4.5, box 4.5). For instance, IBM (United States) partnered with the Bandung local government to establish a traffic management solution, and Huawei (China), with a local partner, established the command and control center for the Bandung Smart City project.

Table 4.5. MNEs participating in the ASEAN Smart City Network (Selected cases)

Company	Headquarters	Company	Headquarters
100 Resilient Cities	United States	EMC	Norway
ABB	Switzerland	EDF	France
Accenture	Ireland	Engie	France
Acronis	Switzerland	GE Healthcare	United States
Aecom	United States	General Electric	United States
Alibaba Cloud	China	Hitachi	Japan
Arup	United Kingdom	Honeywell	United States
Aurecon	Australia	Huawei International	China
Autodesk	United States	IBM	United States
Azbil Corporation	Japan	Johnson Control	United States
B+H Architects	Canada	Robert Bosch	Germany
Black & Veatch	United States	SAP	Germany
Danfoss	France	Siemens	Germany
Dassault Systèmes	France	Tencent	China
Dell	United States		

Source: Ministry of Foreign Affairs, Singapore (2018).

Box 4.5. Participation of MNEs in smart cities development in ASEAN

Smart cities development is taking place across ASEAN. In the development and connection of smart cities in the region, many MNEs are playing a role such as building, supplying technology solutions and investing in them.

Bandung Smart City project

In 2017, the Indonesian Government kicked off an ambitious digitalization programme to build 100 smart cities under the "Gerakan 100 Smart Cities" programme. The Bandung Smart City is one of them. The transformation involves participation by local and foreign technology solution providers. Foreign MNEs include Huawei (China), providing Huawei Smart City solutions. Through collaboration with global security solution providers such as SAP (Germany), Intergraph (United States), Thales (France) and VCS (Netherlands), Huawei provides an end-to-end public safety smart city solution that focuses on omni-protection, rapid response and efficient case-solving. In May 2015, Huawei and State-owned telecommunication company Telkom built a command centre with monitoring cameras throughout Bandung. In the same year, IBM (United States) set up the Bandung Intelligent Operation Center to monitor road traffic. It analyses traffic camera data for accident management, volume analysis and traffic violation detection. French companies are also participating in the development of smart cities in Indonesia. Dassault Systèmes (France) is supplying 3D design and engineering software, Parkeon is supplying smart transportation and parking solutions, and Engie is providing energy transition technology and engineering consultancy from Tractebel.

Singapore Smart City development

Singapore is building a smart city that encompasses extensive application of digital technologies such as IoTs, big data and AI. The Government encouraged private sector participation in the development of digital infrastructure and supply of technologies. The aim is to provide an efficient and connected urban and business environment involving (i) a national digital identity programme, (ii) e-payment systems, (iii) smart nation sensor platform,[a] (iv) smart nation mobility[b] and (v) Go business.[c]

The development of the smart city is expected to improve the efficiency of the Island-state for businesses and investment, including providing investment opportunities for digital and technology solution providers. Key areas for private investment include digital infrastructure and ICT connectivity, Industry 4.0 technologies (hardware and software), financial institutions and health care. Singapore's smart nation[d] transformation involves participation from government institutions, the local private sector and MNEs. In the development of the smart city, MNEs are playing an active role. For instance, iText Software, DocuSign, Adobe, OneSpan and Kofax (all United States) are participating in the development of a national digital identity. Aviva (United Kingdom) partners with the Government on the MyInfo insurance services. With local banks, foreign banks are participating in the city's e-payment systems. These banks include Citibank (United States), HSBC (United Kingdom), Maybank (Malaysia) and Standard Chartered Bank (United Kingdom). Siemens (Germany) is helping establish a digitalization hub to develop innovations for the IoT and Industry 4.0. Supported by the EDB, the hub will complement the country's efforts to become a smart nation, using Siemens IoT operating system MindSphere to drive digitalization.

Sources: Singapore Smart Nation website (https://www.smartnation.gov.sg/what-is-smart-nation/initiatives) and media.

[a] Smart nation sensor platform enables everyone and everything, everywhere, to be connected all the time. It enables stakeholders to leverage on technology and connectivity towards improving lives and businesses in a smart nation.

[b] Refers to application of technologies to increase comfort, convenience and reliability of public transport systems.

[c] GoBusiness is an online platform to connect business owners to various Government e-services and resources. This includes registering a business, and applying for licences and grants.

[d] A smart nation relates to people and businesses empowered with increased access to data, more participatory through the contribution of innovative ideas and solutions, and a more utilization of technology to better serve citizens' needs.

The development of ASEAN smart cities is supported by technology enablers and solution providers offering technologies such as (i) geospatial databases to monitor various aspects of city development, (ii) urban spatial data information systems, (iii) data analytics to support city operations and drive innovation, (iv) ICT networks and connectivity, (v) automation technology and (vi) e-payments and digital platform activities.

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Regional digital cooperation has intensified in recent years. This reflects the commitment of the Member States to advance technology development and adoption to transform ASEAN into an efficient and technologically connected region. A number of major ASEAN agreements, action plans and cooperation documents have implications for strengthening the region's digital ecosystems that relate to promotion of investment in ICT and improved interoperability, technology-driving industries, digital infrastructure (such as broadband access), upgrade of submarine cables, digital connectivity and reduction of international mobile roaming charges.[19] Member States are also cooperating on skills and human resource development such as capacity-building on technologies and innovation in relation to smart factories, digital value chains and digital literacy.[20] Regional cooperation in the various ICT and digital areas opens up market and investment opportunities for MNEs participation.

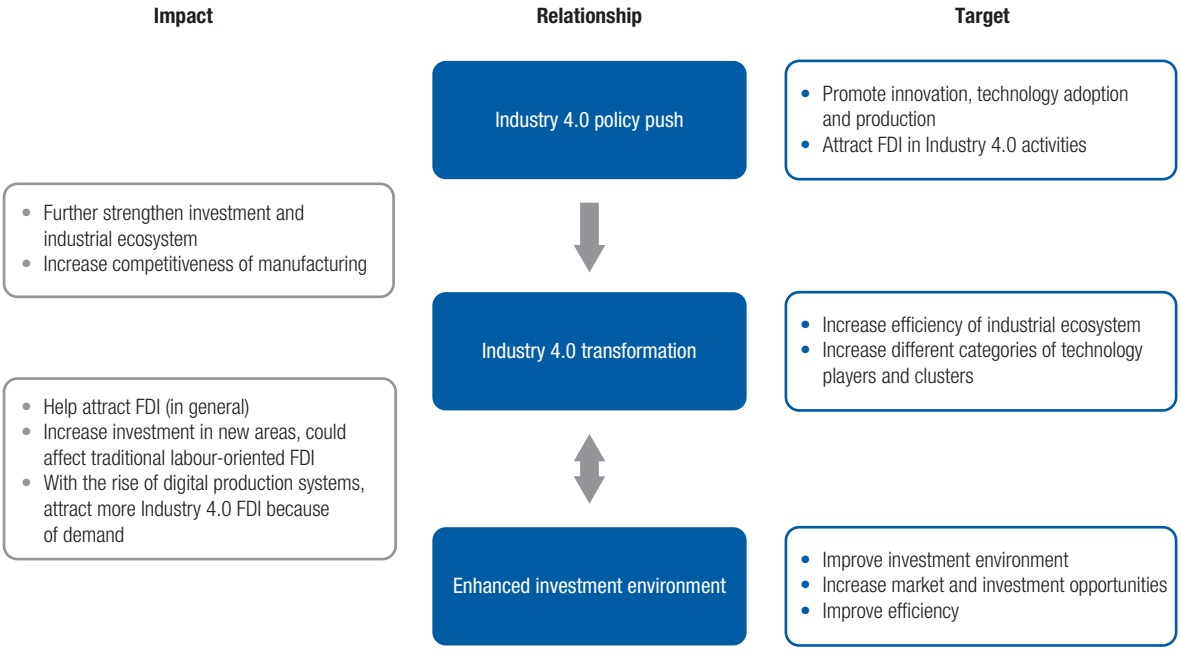
4.4. IMPLICATIONS OF INDUSTRY 4.0

The adoption of Industry 4.0 technologies is expected to have a significant impact on improving manufacturing capability and efficiency in ASEAN. It can enhance the region's manufacturing capacity and support greater participation in global value chains. Transformation to Industry 4.0 could yield up to $0.6 trillion in additional GDP annually through manufacturing productivity gains in ASEAN by 2025 (McKinsey, 2018).

FDI and Industry 4.0 development have an important symbiotic relationship (figure 4.2), each supporting the growth of the other. In particular, (i) promotion of Industry 4.0 is likely to improve the ability of ASEAN to attract FDI by increasing the attractiveness of the investment environment and by offering a more efficient manufacturing landscape resulting from technology adoption by industries and (ii) an improving FDI environment in turn can affect Industry 4.0 transformation by helping bring about an enhanced digital ecosystem and by attracting different categories of technology players. An efficient manufacturing hub from technology adoption also attracts manufacturers that produce Industry 4.0 hardware (equipment, parts and components) and software solutions, including services that support Industry 4.0 manufacturing functions.

This section analyses the Industry 4.0 ecosystem as a key determinant in attracting FDI, following from the analysis in chapter 3 on the role of FDI and MNEs in the development of Industry 4.0 ecosystem.

Figure 4.2. Symbiotic relationship between Industry 4.0 development and FDI environment



Source: ASEAN Investment Report 2020–2021 research, based on analysis in sections 4.3 and 4.4.

4.4.1. FDI and the Industry 4.0 ecosystem

FDI and MNEs have been playing a key role in the development of Industry 4.0 and the digital ecosystem in the region (chapter 3). This takes place through investment in (i) different segments of Industry 4.0 technologies, (ii) different business functions, (iii) cluster development and (iv) development of digital and industrial infrastructure.

The existence of diverse MNEs operating in different technology segments helps enrich digital ecosystems. For instance, the presence of *AWS* (United States) in ASEAN has benefited other companies and supported digital development in the region. It has provided start-ups, local companies and MNEs in the region with smart technology and scalable digital solutions to improve and expand operations. *Daifuku* (Japan) offers industrial automation technology solutions, and *ABB* (Switzerland) has established Robotics Application Centers in a few ASEAN countries to support the growing base of manufacturers. *NTT Data Center* (Japan), through its cloud, AI, big data and blockchain solutions, draws in IT-related foreign partners in developing solutions and services for customers in Southeast Asia. MNEs such as Samsung (Republic of Korea) and Intel (United States) are helping turn Viet Nam into a significant node in global value chains in electronics, with some MNEs investing in automation technologies to increase efficiency. Other Industry 4.0 enablers are also playing an important role in the development of the digital ecosystem (table 4.6).

Table 4.6. Industry 4.0 ecosystem players in ASEAN (Selected cases)

Company/nationality	Industry 4.0 Category	Contribution
Equinix (United States)	Digital infrastructure (data centre)	Links the region with the rest of the world through the Equinix platform and its worldwide partners, customers and stakeholders. Provides data centre services to cloud companies in the region.
Nokia (Finland) Ericsson (Sweden)	Digital infrastructure (4G and 5G networks)	Supports ASEAN telecommunication operators in building ICT connectivity, including 5G networks.
Keppel DC (Singapore) Epsilon (United Kingdom)	Digital infrastructure (data centre)	Supports digitalization and digital connectivity in ASEAN through data centre development, thereby strengthening the ecosystem.
Alibaba (China)	Digital infrastructure (data centres, cloud service and e-commerce)	Supports the ecosystem by investing, developing data centres, providing cloud services and developing e-commerce and linkages with local SMEs. Also developing e-logistic facilities for distribution of products in the region. The Alibaba Cloud ecosystem offers training programmes to partners to help them in digital migration.
ABB (Switzerland) Daifuku (Japan) Universal Robots (Denmark)	Industrial automation and robotic technology solutions	Supports robotic solutions and robot installations in factories in the region.
Microsoft (United States)	Cloud and IoT services provider	With other major players (e.g. Amazon, Facebook, Google), helps strengthen the cloud industry with a presence in at least seven ASEAN countries and is expanding in the region.

Sources: Company websites, annual reports, press releases and media.

The improving digital ecosystems attract other players into the industry, further strengthening the development of clusters and increasing the attractiveness of the general investment environment.

4.4.2. Industry 4.0 impact on FDI environment

Adoption of Industry 4.0 technologies can improve the efficiency and productivity of the manufacturing industry, which will help lower transaction costs for investment and production. This will lead to a more attractive FDI environment, not just for manufacturing but for all industries. A growing Industry 4.0 ecosystem and clusters of different Industry 4.0 players can facilitate easier access to hardware and technology solutions for foreign and local firms to upgrade their manufacturing systems. Growing demand for digital solutions and equipment, and prospects for further growth, will attract more market-seeking FDI both in general and specifically in Industry 4.0 activities. Some technology MNEs have established skills and training centres, which help with industrial upgrading and help improve the investment ecosystem. Industry 4.0 can have an impact on the following aspects of the FDI environment and on regional integration:

(a) Access to Industry 4.0 technologies

The pace of adoption of industrial automation has been increasing in ASEAN, mostly in automotive and electronics industries. However, other industries such as plastics processing, metal forging, consumer goods, and food and beverage production are also adopting automation and other Industry 4.0 technologies. The existence and proximity of industrial automation solution providers to local and foreign manufacturers is important in the transition (box 4.6). Many ASEAN companies such as PT Bogasari, PT Indolakto (both Indonesia); Davao Union Cement (Philippines); Siam Cement, Thai Beverage Group (both Thailand); and VinFast, Vinacomin (both Viet Nam); as well as foreign companies (e.g. Acecook (Japan), Afton (United States), Astra International (Hong Kong, China) and Scancom (Denmark)) have adopted automation and smart manufacturing technology with support from foreign solution and hardware providers operating in the country or in the region.

Digitalization of manufacturing has led to predictive maintenance, enable remote control of operation and real-time access to data, and support more informed decision making. The adoption of digital technologies in manufacturing has led to firms experiencing improved efficiency and reduced operation costs (box 4.6).

Box 4.6. Manufacturers in Thailand are adopting and investing in Industry 4.0 technology

Local Thai companies and foreign MNEs are adopting automation and other Industry 4.0 technologies in various industries, primarily in the automotive and electronics industries. For instance, *UTAC Holdings* (Singapore) offers semiconductor assembly and testing services for integrated circuits. The firm's three factories are heavily automated. Automated processes allow the firm to meet rapidly changing demands from customers.

Denso Ten (Japan) is a first-tier automotive part supplier. It manufactures audiovisual products and automotive electronics. Since Industry 4.0 technologies were introduced to its factories in Thailand in 2015, productivity has increased by more than 50 per cent.

Siam City Cement (Thailand) has established an Industry 4.0 plant with robot-assisted inspections, predictive maintenance capabilities, data analytics and machine learning technologies. Other Thai conglomerates such as *Thai Beverage and Charoen Pokphand* have also adopted automation and other smart technology systems in their manufacturing activities.

A United States manufacturer of hard disk drives interviewed for this report adopted Industry 4.0 technologies (e.g. machine learning, the IoT, big data, failure prediction) in 2015. The economic return on investment on these technologies to the company is more than 100 times the cost.[a] The company perceived that the pace of introduction of Industry 4.0 technical parameters that local suppliers in Thailand need to comply with will increase substantially. Although local suppliers can provide components and parts with sufficient quality, they may not be able to meet new demands, so the company is planning to provide technical assistance to those suppliers.

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Box 4.6. Manufacturers in Thailand are adopting and investing in Industry 4.0 technology (Concluded)

Another major United States manufacturer of hard disk drives interviewed for this report has R&D facilities in the United States and Singapore, and production facilities in Malaysia, Singapore, Thailand and in other countries. The company adopted a vertical integration strategy, internalizing the whole value chain from R&D to product design, to manufacturing of components and products.[b] It viewed itself as a data storage service provider, not only a hard disk drive maker. It has planned for and implemented Industry 4.0 in its Thai facilities since 2012, following on its implementation of Industry 3.0 technologies, which started in about 2000 and focused on automating production processes. The company aims to achieve Industry 4.0 in two aspects: designing and manufacturing hard disk drives, and applying technologies to become a leading provider of data storage services. For hard disk drives, the application of Industry 4.0 technologies will enable the company to digitally connect cyber and physical systems in one seamless operation. To achieve this, the firm has been providing both online and on-site training to develop data scientists and engineers with new skill sets and mindsets. As a result of its implementation of Industry 3.0 and 4.0 technologies, the number of workers producing hard disk drives declined from 30,000 to 2,000.

MNEs are undertaking FDI in activities related to Industry 4.0 in Thailand, driven by promising prospects for adoption of technology in the manufacturing industry (box table 4.6.1).

Box table 4.6.1. MNEs investing in Industry 4.0 activities in Thailand

Name	Nationality/ownership	Main activities	Year
Kaneta Mechatronic Engineering	China	Automation and automation system integration	2018
Kuroda Techno Tooling Machine	Japan	Automated system and ultrasonic soldering	2020
Schaeffler EMC	Switzerland	Electronic control and measurement for medical devices, and industrial and agriculture uses	2018
Chicony Electronics	Taiwan Province of China	Security control equipment	2020
Shinkawa Manufacturing Asia	Japan	Automation machinery and system	2020
China Telecom	China	Cloud service	2020
Sony Device Technology	Japan	Advanced technology hard disk drive and components	2020
Digital Software Consulting	United States	High value added software for big data, data analytics, predictive analytics and business process management	2018
Toyota Motor	Japan (86%), Thai (14%)	Plug-in hybrid and battery electric vehicles and parts	2020
Toshiba	Thai (54%), Japan (46%)	Smart electrical appliances	2019, 2020
Nissan Motor	Thai (25%), Japan (75%)	Battery electric vehicles and parts	2020
Mitsubishi Motors	Japan	Plug-in hybrid and battery electric vehicles and parts	2019, 2020
Huawei Technology	China	Cloud service	2019
Honda Automobile	Thai (36%), Japan (64%)	Battery electric vehicles and parts	2020

Source: BOI of Thailand.

Source: ASEAN Investment Report 2020–2021 research, based on Intarakumnerd (2021) and media.
[a] Interview with the company in April 2021.
[b] Interview with the company in May 2021.

(b) Improving manufacturing efficiency

Digitalization of manufacturing has led to predictive maintenance, enabled remote control of operation and real-time access to data, and supported more informed decision making. The adoption of digital technologies in manufacturing has led to firms experiencing greater efficiency and reduced costs of operation (box 4.7).

Box 4.7. Impact of Industry 4.0 technologies on manufacturing efficiency in ASEAN

Many firms have reported improved manufacturing efficiency from application of Industry 4.0 technologies. The cases below offer some corporate examples.

Amgen (United States) established a smart manufacturing plant in Singapore that enabled the company to carry out data analytics across products and sites to predict overall performance, quality and the likelihood of successfully manufacturing additional batches without extending production schedules. The system nearly halved the volume of process monitoring documentation, saving the company 1,200 person-hours. This has allowed the manufacturer to improve productivity and business performance.

Bosch (Germany) opened a smart manufacturing facility in Thailand in 2017 in response to rising demand from clients for automotive parts and components. The facility produces injection valves, connection technology, knock sensors and other components. Industry 4.0 solutions enable the plant to bring together a wide range of information in real time and help improve production efficiency.

DHL (Germany) in Indonesia adopted smart workplace solutions by Huawei (China), which helped the former digitalize all its operations with the use of real-time big data management. DHL's supply chain operation in Indonesia has improved in terms of procurement, labeling and delivery performance, reducing both customer complaints and work hours.

PT Indolakto (Indonesia), a diary product manufacturer, received technology solutions support from Koerber (Germany), an automation and supply chain solutions company, to implement an automation system in its Surabaya distribution centre. The system expanded production capacity by 25 per cent with automated storage technology. ABB (Switzerland) also supplied a robotic technology solution to PT Indolakto.[a]

Sanwa Group, a plastics manufacturer in Singapore, adopted smart manufacturing and automation solutions with support from Schneider Electric (France). The automated solution supported remote monitoring of energy consumption and IoT data monitoring of temperature, humidity and pressure; it enabled a centralized command station to remotely manage operations and access real-time data.[b] The automated production facilities (i) relieved staff to perform and upskill for more valuable tasks, (ii) doubled production output, (iii) enabled faster and better diagnostics, (iv) reduced energy consumption and associated costs and (v) resulted in near zero defective production.

Schneider (France) implemented an IoT-enabled automation platform in a factory in Indonesia, leading to an increase in labour productivity by interconnecting machines, streamlining the communication process and improving the accuracy of data captured and analysed. The platform combined the IoT, mobility, sensing, cloud, analytics and cybersecurity technology.

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Box 4.7. Impact of Industry 4.0 technologies on manufacturing efficiency in ASEAN (Concluded)

Siam City Cement (Thailand) started its digital transformation in 2017, aiming to achieve a more efficient and safer operation environment, and high-quality production output. It adopted a smart manufacturing solution in its Saraburi Province plant with technology provided by Fujitsu (Japan). The factory incorporated various Industry 4.0 technologies such as robot-assisted inspections, data analytics for predictive maintenance, machine learning and a remote operation centre. The factory recorded a 2 per cent improvement in annual overall equipment efficiency and a 10 per cent decrease in maintenance costs.[c] The smart manufacturing solution also enabled preventive maintenance, thereby avoiding unplanned downtime and increased productivity.

PT Nusantara Parkerizing (Indonesia) established an automated warehouse with support from Daifuku (Japan). The automated warehouse improved efficiency in the control of raw material supply, facilitated production plans and enabled the company to implement first-in, first-out of raw materials and products effectively.

In Viet Nam, a semi-automated *Tan Thang* cement plant underwent further automation in 2018. ABB supplied and installed additional integrated digital automation and electrical equipment. It provided technology for integrating the control, electrical and communication systems for optimal visibility into all processes to achieve stable production and efficient use of raw materials and energy. The transformation is expected to increase production to 2 million tons of cement per year.

Vinacomin Motor Industry, a subsidiary of State-owned Vinacomin Group (Viet Nam), also adopted further automation technologies in 2018. Universal Robots (Denmark) supported some automation aspects of the production plant, which deploys collaborative robots. The company has seen productivity increase two to three times, with improved product quality, leading to a 50 per cent to 60 per cent per cent rise in orders. Automation relieved workers to perform higher-level tasks, which in turn increased worker satisfaction. The return on investment in Viet Nam for such robotic investment is typically between six and eight years, but the company expected to reach it within a shorter period. The company aims to add three to five more collaborative robots to automate more processes in the next few years.

Sources: Company websites, industry reports and media.
[a] *BeritaJatim*, "ABB shows robotic technology for Mamin", 17 September 2019.
[b] Schneider Electric, "Sanwa Group customer story" (https://www.se.com/ww/en/work/campaign/life-is-on/case-study/sanwa-group.jsp).
[c] Fujitsu, "Smart factory ready for wider adoption, promising to transform manufacturing business" (https://www.fujitsu.com/th/en/themes/enabling-digital/asia/smart-factory/articles/smart-factory-productivity-in-thailand.html).

The application of IA and robotic technology in ASEAN has helped manufacturers address key challenges, such as overcoming tight labour pools and improving product competitiveness, efficiency and industrial safety. Other benefits from digitalization of manufacturing and deployment of automation are itemized in table 4.7.

Sritex (Indonesia), a major textile and garment manufacturer, invested about $100 million in upgrading its production facilities with automation, robotization and digitization of manufacturing. The application of Industry 4.0 technology occurred at each segment of its value chain. The design system was digitized, the weaving system uses robotic technology with a programmable logic controller system, the spinning process uses robotics to pick up items,

Table 4.7. Benefits from deployment of industrial robots and cobots in ASEAN (Some examples)

Company/location	Activity	Technology application	Benefits
Benchmark Electronics (Thailand)	Engineering, manufacturing and integrated technology solutions provider	Deployed collaborative robots for assembly and testing tasks in its production facility in Korat	Higher-quality output with fewer errors. Operational efficiency improved by 25 per cent, and manufacturing space declined by 10 per cent. Operators transferred to higher-skilled jobs, involving complex assembly processes, with the integration of cobots in the manufacturing operation.
Clearpack (Singapore)	Packaging automation solutions provider	Designed an automated palletizing solution comprising cobot and motion technologies	Helped customers in the fast-moving consumer goods sector optimize warehouse space.
PLC Industries (Singapore)	Precision machining	Installed cobots at its production facility	Manufacturing output increased by 40 per cent. Benefited from the dexterity and flexibility of robotic arms with minimal supervision. Relieved workers to attend to more machines.
PT JVC Electronics (Indonesia)	Electronic and entertainment products manufacturer	Deployed seven collaborative robots from Universal Robots (Denmark)	Improved productivity and production processes, and achieved consistent output and worker safety. Reduced yearly operation costs by more than $80,000.
Sky Engineering (Singapore)	Precision engineering	Installed robotic arms in the production process	Enabled one worker to attend to two machines, thus reducing production costs.

Sources: Company websites and Universal Robots.

coloring work uses a digital print system and additive manufacturing technology supports more individualized production (Sirine and Andadari, 2019). Sritex used an integrated enterprise resource planning system to connect data from the production division, marketing, logistics, human resources to finance and accounting. This system created automatic coordination of the entire company, as all data can be accessed and analysed in real time. The application of these digital technologies helped Sritex reduce production costs. Some processes were shortened (cutting time and reducing resources required); for example, the production process from yarn to finished goods now takes two weeks as compared with one month before.

(c) Skills development and training facilities

Some MNEs have contributed to skills development through training programmes and in the process contribute to upgrading the skills of workers, who can be freed to perform higher value added tasks. In addition to providing dedicated training to support customers, some MNEs have set up centres of excellence that include training functions, as well as training centres to help clients transition to Industry 4.0 and to gain knowledge on the application of digital technologies. Some have also partnered with universities and institutions for courses and training modules. Human resource development and skills upgrading will strengthen technological capacity and capability in ASEAN to attract investment, including in activities related to Industry 4.0.

Delta Electronics (Taiwan Province of China) supported developments of industrial automation skills in Thailand through collaboration with local institutions. It established Delta Automation Academy, which offers industrial automation courses for undergraduates and Delta Industrial Automation Laboratories in three local universities. Siemens (Germany) has partnered with educational institutions and governments in some ASEAN Member States to provide training and student access to its technology software and hardware. It partners with the Singapore Institute of Technology and the Department of Technical and Vocational Education and Training in Yangon, Myanmar. Bosch (Germany) is one of the initial partners in the Digital Transformation Acceleration Programme with the MDEC to help the Malaysian Government promote Industry 4.0. It is also partnering with a local education agency in Kedah, which is a skills and management development centre, to use Bosch educational tools to train students and workers to be Industry 4.0 ready. Bosch also hosts masterclasses for SMEs to introduce Industry 4.0 solutions.[21] ABB (Switzerland) has carried out and supported digital skills development and training in ASEAN (box 4.8). In 2018, Huawei announced an $81 million investment to build OpenLabs, to cultivate ICT talent in Southeast Asia.

In Thailand, Denso Ten (Japan) transfers technologies to local suppliers through its Lean Automation System Integrators programme by using its engineers, most of them from Japan, as master trainers. In close partnership with Department of Industry Promotion under the Ministry of Industry, universities (especially the Sirindhorn International Institute of Technology under Thammasat University), and other educational institutions, the programme develops

Box 4.8. ABB: training programmes on digitalization in ASEAN

ABB has established various training facilities in partnership with local institutions in ASEAN, including in the following ASEAN Member States:

Indonesia

ABB established an R&D centre, which is aligned with the human resources development policy of the Indonesian Government to accelerate preparations for realizing Industry 4.0. It also partners with the Institute of Technology Bandung, supporting development of skills in power technology.

Malaysia

ABB has set up an ABB University to offer training programmes for engineers, programmers, maintenance and operations personnel.

Thailand

ABB has established a partnership with Panyapiwat Institute of Management to support the training of the workforce of the future in innovation needed by industry. It has supplied and installed industrial robots and a collaborative robot at the institute so that students can learn and use the technologies through a work-based education process.

Viet Nam

ABB trains local workers for its operation in Viet Nam.

Sources: ABB and media.

personnel who can implement lean automation in robotics and the IoT. In addition, some major manufacturers of hard disk drives in Thailand are collaborating with local universities (e.g. King Mongkut's Institute of Technology Ladkrabang) in research on and use of Industry 4.0 technologies. A United States manufacturer of hard disk drives interviewed for this report collaborated in research and human resource development with 18 Thai universities under the Talent Mobility Programme, which enables Thai university professors and researchers to work at private companies for a specific amount of time. The company has an early recruitment programme to recruit university students in their fourth year, before graduation, to work in the company on Industry 4.0 technologies.

(d) Regional development and integration

Realization of Industry 4.0 can help strengthen ASEAN's regional integration through cross-border investment, production, industrial connectivity and through both intrafirm and interfirm linkages. Movement toward Industry 4.0 could accelerate the regional division of labour, with labour-intensive production processes directed to low-cost, labour-abundant Member States, while other Member States will push for faster adoption of technologies that can reduce demand for labour.

Regional integration could also be strengthened with cooperation in innovation, in production and in adoption of Industry 4.0 technologies through the various ASEAN initiatives related to digital development, e-commerce and the smart cities network. In addition, FDI by MNEs, including intra-ASEAN investment in digital activities can connect industries and production in the region. Examples include technology SMEs from ASEAN investing and establishing operations in other ASEAN Member States, technology MNEs strengthening their value chains with different operations and in different segments of their business operations across ASEAN, and ASEAN corporate venture capital firms funding technology start-ups based in other ASEAN Member States (section 4.4.3). An integrated, efficient and more connected ASEAN through adoption and development of Industry 4.0 technologies can help the region further attracts FDI.

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Although Industry 4.0 could lead to greater efficiency, it could also have both positive and negative impacts on Member States' ability to attract FDI. For instance, Industry 4.0 could affect the ability of Member States to attract labour-intensive FDI activities because of automation and technologies that replace labour (table 4.8). This will have an important consequence for lower-cost labour locations – an emerging issue that requires attention. At the same time, Industry 4.0 can also provide opportunities to attract new types of investment, particularly those related to digital infrastructure, cloud computing, technology centres, and the broader digital economy, including for start-ups. Another important impact of Industry 4.0 is on strengthening the region's investment environment, which in turn can help attract FDI in general. Industry 4.0 transformation can also provide opportunities to Member States to attract FDI in manufacturing that relates to production of technology equipment, parts and components.

Table 4.8. Industry 4.0 impact FDI attraction in ASEAN

Type of FDI	Increase ability	Reduce ability	Reasons
Investment environment	●		• Improve efficiency and investment environment • Increase ability to attract FDI in general
Labour-intensive activities		●	• Technology replaces labour • Location choice based on overall cost efficiency influence led by technology application • Production can be controlled and managed remotely (smart factories)
Digital infrastructure investment (5G networks, data centres, hyperscale broadband width)	●		• Market opportunities and growth drive demand for digital infrastructure (e.g. rapid rise of the digital economy) • Policy push towards digitalization • Improve investment environment and digital connectivity that enables Industry 4.0 application
Industry 4.0-related investment (e.g. additive manufacturing, the IIoT, automation, smart factories)	●		• A manufacturing powerhouse, a large pool of manufacturers – market potential for technology suppliers • Policy push targeting Industry 4.0 transformation • Industrial upgrading and technology adoption by more firms – improve efficiency and competitiveness of the manufacturing industry
FDI in R&D, technology centres and centres of excellence	●		• MNEs investing in technology and R&D centres to be close to clients, to facilitate adoption and adaptation • Centres of excellence and demonstration effects
FDI in the digital economy (e.g. e-commerce related industries, fintech, delivery)	●		• Increase investment and players in digital infrastructure • Rapid growth of the digital economy and ecosystem, including start-up environment • Increase enterprise connectivity, from sourcing and production to markets

Source: ASEAN Investment Report 2020–2021 research, based on analysis in section 4.4.

4.4.3. SMEs, digitalization and Industry 4.0 transformation

SMEs can be significant players in the Industry 4.0 ecosystems as investors, manufacturers, service providers and users of technologies. They account for up to 99 per cent of business establishments, contribute to more than 50 per cent of ASEAN's gross domestic product and employ more than 80 per cent of the workforce in the region (ASEAN Secretariat, 2019). Hence, they form a potentially large market for technology equipment, solutions and training when they upgrade their operations. As such they can be a major driver of FDI in Industry 4.0 activities in ASEAN.

The role of SMEs in Industry 4.0 transformation could be strengthened by supporting them in adopting technology to upgrade, to be major players in the Industry 4.0 supporting industries, and to innovate and adapt technologies suitable for other SMEs. In further strengthening the Industry 4.0 ecosystems, efforts to promote technology start-ups are necessary, and they in turn can help attract foreign and ASEAN venture capitals. Promoting FDI by SMEs in Industry 4.0 activities, including supporting SMEs and technology start-ups to regionalize in ASEAN can also enhance the ecosystems.

The internationalization of SMEs in ASEAN is low. Less than 10 per cent of SMEs in the region are involved with FDI, according to a recent survey of 1,763 SMEs in ASEAN (ASEAN Secretariat, 2021). SMEs in ASEAN have already established important links in internationalization involving digital transformation and with MNEs. These links involve various channels, which include (i) vendor relationships between MNEs and SMEs for technology upgrading, (ii) MNEs with specific Industry 4.0 technology programmes that target the digital transformation of ASEAN SMEs, (iii) technology that enables SMEs to expand their market reach, (iv) technology start-ups in ASEAN that scale up with regionalization, and (v) ASEAN and foreign venture capitalists supporting regionalization of technology start-ups.

The internationalization of SMEs is an important aspect of the action plan in the AEC Blueprint 2025. ASEAN Member States are cooperating at the regional level and have adopted national plans to support the development of SMEs, including internationalization and adoption of digitalization technology to improve their efficiency and productivity. However, to strengthen the AEC process and regional connectivity, more needs to be done to help SMEs build competitiveness and regionalize. Even more needs to be done to help SMEs improve efficiency by upgrading operations and using technologies for product development, production processes and reaching out to the expanding regional market.

This section examines the role of SMEs in Industry 4.0 development, their adoption of technology, their digital transformation and their link with FDI and MNEs, and challenges limiting them to transition. Policy options to increase technology adoption and linkage with MNEs are provided given their role in Industry 4.0 ecosystems.

(a) SMEs slow pace of digital transformation

Most SMEs in the region can be categorized as operating in an Industry 1.0 environment, with basic technology and mechanization processes (DEPA, 2020; see box 4.1). SMEs are less adaptive to digitalization than large corporations. Only 13 per cent of the 1,763 ASEAN SMEs recently surveyed used cross-border e-commerce technology solutions in 2020 (ASEAN Secretariat, 2021). The number of SMEs adopting digital technology for manufacturing are even much smaller. However, an increasing number are adopting digital technologies to communicate and expand market reach through social media and e-commerce platforms. The pandemic has accelerated the pace of digital adoption and the use of e-commerce platforms by SMEs to market products and services, and to source materials.

Internationalized SMEs have a greater tendency to use data analytics and cloud-based solutions to improve their understanding of their customer demographics and assess the effectiveness of their advertising. Usage of more advanced technologies such as the IoT and AI is still limited for all SMEs. If the region is to advance with Industry 4.0 transformation, then this rate needs to be addressed, as SMEs form the largest pool of enterprises and play an important role in developing supporting industries and in the industrial ecosystem overall. Competitive SMEs, supported by Industry 4.0 technologies, would augur well for ASEAN's investment environment and for improving the efficiency of the region's manufacturing industry.

Current SME investment in digitalization focuses mainly on front-end operations such as establishing a digital presence and marketing (e-commerce platforms and digital marketing) (Ernst & Young, 2019; OUB, Accenture and Dun&Bradstreet, 2020; GrabFinance and Bloomberg Media Studios, 2020). In general, SMEs recognize the benefits of these technologies for improving competitiveness and for expanding their operations. Although digital transformation is still low among SMEs, an increasing number are planning or starting to invest in and upgrade their use of technology (table 4.9), among them automation and robotics, AI, predictive analysis, big data, the IoT, blockchain and cybersecurity.

Table 4.9. Digital technology plans of SMEs in ASEAN

Survey	Number of SMEs	Current technology investment	Technology investment within five years
Ernst & Young 2019 SME Survey[a]	370	77 per cent: • E-commerce platforms • Market outreach digital solutions • Enhanced payment system	76 per cent: • AI • Big data, machine learning • Robotics process automation
OUB, Accenture and Dun & Bradstreet 2020 SME Survey[b]	1 000	64 per cent: • Digital technologies to drive sales (i.e. e-commerce, digital marketing) • Network management system • Subscription-based ICT services (i.e. online payment)	56 per cent: • Digital sales, services and marketing • Technology/network management • Operational processes (i.e. robotic and automation technology) • Cybersecurity
GrabFinance and Bloomberg Media Studios 2020 SME Survey[c]	600	58 per cent: • E-commerce • Social media • Mobile apps • Software for streamlining business procedures • Cloud computing and technology led solution for supply chain, inventory and cash management and apps on business forecasting and analysis) • Online payments	51 per cent: • AI, robotics, automation • Big data, IoT, blockchain, machine learning • 3D printing • Cybersecurity • E-commerce • 5G

Sources: Respective surveys.
Note: AI = artificial intelligence, IoT = internet of things, SMEs = small and medium-size enterprises.
[a] Ernst & Young (2019). The survey covers six countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam).
[b] OUB, Accenture and Dun&Bradstreet (2020). The survey covers five countries (Indonesia, Malaysia, Singapore, Thailand and Viet Nam).
[c] GrabFinance and Bloomberg Media Studios (2020). The survey covers four countries (Malaysia, Singapore, the Philippines and Thailand).

The pandemic has accelerated the digitalization of SMEs in the region. Most of the current technology deployment by SMEs is to increase business activities and facilitate revenue generation (e.g. using third-party e-commerce platforms, digital marketing, enhanced payments, social media) (OUB, Accenture and Dun & Bradstreet, 2020; Grab Finance and Bloomberg Media Studios, 2020). The pandemic posed additional challenges to SMEs in ASEAN (e.g. limited access to digital facilities hamper access to markets and to generate revenues during lockdown). However, some SMEs have been able to digitalize by using the services offered by technology start-ups and MNEs (e.g. e-commerce and digital marketing platform, and cloud computing services) (box 4.9). For example, unicorns (e.g. Grab, Gojek) and start-ups (e.g. LinkAja in Indonesia) in ASEAN provided facilities to support SMEs' digitalization to mitigate the impact of the pandemic-induced economic downturn.[22]

Box 4.9. ASEAN technology start-ups and banks assist SMEs with digitalization during the pandemic

Some ASEAN technology start-ups and banks are helping SMEs with online, e-commerce and other digitalization facilities. The cases below provide selected examples of digitalization initiatives extended to SMEs during the pandemic.

Indonesia

Grab (Singapore) introduced an app (GrabMerchant) in Indonesia that provides a one-stop service platform for micro and small- and medium-sized enterprises (MSMEs) in food and beverage operations to manage operational hours, orders, employees, menus and promotions. Food and beverage MSMEs can also purchase supplies at a special price through Grab's online grocery marketplaces, TaniHub and Sayurbox. Both grocery marketplaces provide next-day delivery to Grab's 100,000 merchants, mainly MSMEs, in seven cities in the country.

Gojek (Indonesia) has helped about 100,000 MSMEs digitalize their businesses through using its digital solutions and online platforms. Gojek offers MSMEs' customers in-app on-demand services including food delivery (GoFood), an e-wallet (GoPay) and courier service (GoSend). Gojek's app GoBiz allows small businesses to manage their companies online and helps them target potential customers online.

LinkAja, an e-wallet platform for more than 200,000 local merchants, provides promotional incentives to help MSMEs increase digital transactions. Promotional incentives include 20 per cent cash back for purchases in traditional markets as well as 10 per cent cash back for transactions with modern retailers and local merchants at malls. The platform has seen a 64 per cent surge in digital transactions in traditional markets and a 12.8 per cent increase in transactions for modern retailers.

Malaysia

CIMB Bank partnered with e-commerce provider Shopmatic to help Malaysian SMEs build and scale up their e-commerce businesses. The initiative provides SME customers with finance and business solutions, such as SME Financing (for no-collateral and business property financing) and SME Partners (for services such as operations and logistics, e-commerce and digital connectivity). Malaysian SMEs can benefit from Shopmatic's services by setting up an e-commerce site with a secure payment gateway and can receive guidance on technical know-how for starting and running an online business. SME customers can set up their businesses online in less than 30 minutes and with a 30 per cent discount on all subscription packages.

Sources: Company websites and media.

(b) Internationalization of SMEs and adoption of Industry 4.0 technologies

Some ASEAN Member States have adopted measures to support SMEs in Industry 4.0 transformation. They are actively encouraging SMEs and start-ups to innovate and commercialize their innovations. In some, technology SMEs are also encouraged to internationalize and establish business linkages with MNEs to strengthen the supporting industry and the technology ecosystem. Some ASEAN Member States have adopted policies aiming to promote SME-MNE linkages, which also support SME participation in industrial clusters and as part of MNEs' supply chains (OECD/ERIA, 2018).

The Government of Singapore actively encourages public-private collaboration on innovative technologies. For instance, the National University of Singapore Centre for Additive Manufacturing, established in 2017, has signed memorandums of understanding with four local companies for research and product development on additive manufacturing for the biomedical sector, which includes a medical device SME (Dou Yee Enterprises) and a precision engineering SME (Forefront Additive Manufacturing).

The Government of Malaysia provides grants to help SMEs and start-ups grow and expand in the region and abroad. Grants are offered through government bodies, such as the MTDC and the MDEC. Calms Technology, a smart card technology solution SME with 30 employees, has received grants from the MTDC for expansion and funding support for product development from the MDEC. Calms Technology has distributors in Indonesia, Singapore, Thailand and Viet Nam. It offers one-card solutions to more than 400 organizations in different businesses. Some of its major clients in Malaysia include INTI International College (Malaysia), Panasonic Manufacturing Malaysia (Japan), Steelcase Manufacturing (United States) and Malaysia Airports Holdings (Malaysia).

In Thailand, the BOI works closely with the Thai Automation and Robotics Association to facilitate the development of robotic and automation technology. The association developed a robotic system, which includes telemedicine services, to help medical centres care for patients infected with COVID-19. Physicians can command the robot remotely, minimizing direct contact with these patients. Engineering drawings and system details were circulated to more than 20 local robot producers (including mid-sized firms) to upscale production for mass markets. Local producers were provided investment incentives such as a corporate income tax holiday.[23] The BOI has been encouraging Thai firms to expand abroad, setting up the Thai Overseas Investment Support Centre, a one-stop service and training hub for Thai companies planning to internationalize. As of early 2020, the Centre had conducted 17 training courses for 609 companies, which are mainly SMEs aiming to expand overseas.[24]

(1) Regional policy supporting SME internationalization and technology development

ASEAN cooperation on SME development is guided by initiatives highlighted in the AEC Blueprint 2025 and the ASEAN Strategic Action Plan for SME Development (2016–2025). These regional actions include measures to support SME internationalization (e.g. through outsourcing and FDI activities). This section highlights regional actions encouraging SMEs to internationalize, gain access to funding that supports cross-border investment in ASEAN (e.g. venture capital), support technology start-ups and innovation, and adopt technology to upgrade or improve SME competitiveness.

The AEC Blueprint 2025 focuses on strengthening the role of MSMEs through specific action agendas (table 4.10):

(i) Promoting technology, production and innovation. This covers actions to enhance MSMEs' productive capacity, build industry clusters through industrial linkages, promote technology usage and application, and foster closer business-academia linkages.

Other specific measures include (a) enhancing industrial linkages among SMEs and between SMEs and MNEs, (b) building capabilities to foster industry clustering and (c) enhancing the provision of information on innovation.

(ii) Increasing access to finance by developing and enhancing institutional frameworks, including a policy environment that fosters the development of alternative and non-traditional financing channels. Other actions cover the promotion of financial inclusion and the enhancement of MSMEs' ability to benefit from financial systems.

(iii) Enhancing market access and internationalization through schemes that develop market access and integration into global supply chains, including development of business linkages with MNEs. Other measures cover (a) increasing information on regional and global market access and opportunities and (b) enhancing the use of e-commerce.

(iv) Enhancing the policy and regulatory environment to support SME development.

(v) Promoting entrepreneurship and human capital development by creating a more conducive environment for entrepreneurship through the ASEAN On-line Academy, and enhancing human capital development for MSMEs.

Table 4.10. Measures for SME development in the AEC Blueprint 2025 (Selected cases)

Area	Measure
Technology and innovation	Strengthen the competitiveness of the MSME sector in ASEAN through the application of science and technology tools and methodologies.
E-commerce	Encourage MSMEs to use e-commerce platforms to extend market reach. E-commerce channel can significantly lowered barriers to entry and transaction costs for businesses, and can be beneficial for MSMEs.
Financial inclusion	Enhance the financing ecosystem in the region to benefit MSMEs. This includes developing other appropriate facilities or mechanisms that will provide financial access for MSMEs (e.g. venture capital funding).
Consultative process with the private sector	Encourage private sector groups to initiate cluster groups to engage in specific issues and hold partnership events on key issues (e.g. investment, connectivity).

Source: ASEAN Secretariat, AEC Blueprint 2025.

(2) National policy supporting the growth and development of SMEs

All Member States have policies supporting the growth and development of SMEs. Some have specific policies and measures supporting SMEs in digital transformation, internationalization and business linkages between foreign MNEs and local SMEs. Some measures and incentives provided by Member States include (i) fiscal incentives (tax holidays, duty-free importation), (ii) grants and financing support and (iii) institutional support and capacity-building (e.g. coaching, mentorship, building knowledge on internationalization) (table 4.11). For example, Malaysia's SME Digitalization Initiative provides grants to assist SMEs in adopting digitalization, and Singapore offers double tax deduction for internationalization to encourage local businesses to internationalize.

Table 4.11. ASEAN: Support for SMEs' Industry 4.0 transformation (Selected cases)

Support type	Indonesia	Malaysia	Philippines	Singapore	Thailand
Incentives for SME investments (domestic)	✓	✓	✓[a]	✓	✓
Incentives for MNEs collaborating with local SMEs (general)	✓[b]	✓	..	✓	✓
Incentives for SMEs activities in Industry 4.0	✓[c]	✓	✓	✓	✓
Grants for SME development and technology upgrade (digitalization and Industry 4.0)	..	✓	✓	✓	✓
Dedicated agency for SME development	✓	✓	✓	✓	✓
Involvement of investment authority	✓	✓	✓	✓	✓

Sources: Indonesia Investment Coordinating Board, Board of Investments (Philippines and Thailand), Enterprise Singapore, Economic Development Board of Singapore, Malaysian Industrial Development Authority, SPRING (Singapore), and media.

[a] Applies to project activities in agriculture, services, tourism and manufacturing with project costs of $285,000 or less.

[b] Indonesia allows foreign MNEs to operate in some sectors through joint venture with local SMEs.

[c] On condition that the joint venture (foreign MNE or SME) or local SMEs are involved in Industry 4.0 activities in priority industries (e.g. food and beverage, automotive, electronics, chemicals, textile, pharmaceuticals and medical devices).

Institutional support

All Member States have established dedicated institutions to oversee and support SME development. Some have also established coordination mechanisms among key ministries (e.g. in Thailand, coordination between the Board of Investment, Ministry of Trade, Ministry of Science and Technology or Office of SMEs Promotion). Some of these institutions also provide and disburse grants and other financing packages for SME development or SME adoption of Industry 4.0 technologies, such as the MTDC and the MDEC in Malaysia. The MDEC is also running capacity-building programmes including accelerators for SMEs' digitalization.

Some Member States have set up agencies or associations to support SME internationalization and created opportunities to develop business linkages between SMEs and MNEs. For example, Enterprise Singapore, a government agency, champions enterprise development and supports enterprises in building capabilities, innovating and internationalizing). Singapore also has established A*STAR and Spring Singapore, which facilitate innovation and technology adoption, particularly by SMEs.

Cambodia passed Sub-Decree No. 124 ANKr.BK, in October 2018, to incentivize the development of SMEs in priority sectors through income tax holidays and deductible expenditures. These sectors include agricultural or agro-agricultural products; food manufacturing and processing; manufacturing of finished products, spare parts or assembling parts to supply other manufacturers; R&D associated with IT or the supply of IT-based services and enterprises located in SME Cluster Zones and enterprises developing cluster zones. An SME cluster zone (e.g. the $30 million Worldbridge i4.0 SME cluster zone) is being developed to bridge the gap between manufacturing FDI and local SMEs to create and locate complete value chains inside an industrial ecosystem containing supporting facilities, services and ICT platforms.[25] Cambodia's development plans also promote SME linkages with large firms (OECD/ERIA, 2018).

In 2017, Viet Nam's National Assembly passed an SME law that provides incentives for SMEs involved with R&D and technology transfer. The Programme on the Development of Supporting Industry for 2016–2025 (Decision 68/2017) is Viet Nam's main policy on building FDI-SME linkages. The programme addresses the lack of competitive local suppliers by supporting and connecting domestic enterprises with foreign companies to further attract FDI in selected supporting industries: textiles and apparel, electronics, automotive, metal products and high-tech (manufacture of special-use materials and supporting equipment, software and services for high-tech industries). Investment incentives are provided to firms in the supporting industries, including SMEs that engage in R&D activities related to the development of supporting industry products.[26]

(c) SMEs' digital transformation and link with FDI and MNEs

The digital transformation of SMEs in ASEAN entails links with MNEs and cross-border activities. They can take various forms.

MNE-SME vendor relationship influence on technology adoption

Some MNEs are influencing their SME vendors to upgrade technology to improve efficiency, align with production goals and serve the MNE partner effectively (chapter 3). For instance, *PT Asalta Mandiri Agung* (Indonesia), a supplier to Toyota Motor Manufacturing Indonesia (TMMIN) and Denso (Japan), underwent strict audit processes by TMMIN to become its supplier. Toyota and Denso encouraged Asalta to invest in technology. It upgraded manufacturing technology and deployed automation and robotic technology to meet the demands of TMMIN in terms of safety, quality, cost competitiveness and timely delivery. TMMIN provides training and assistance to Asalta in human resource development, including technical support.

Batur Jaya Ceper Unit, an Indonesian SME cooperative, produces cylinder sleeves to supply a TMMIN level 1 local supplier (PT TPR Indonesia) that produces pistons ring. Batur Jaya Ceper underwent a training programme conducted by TMMIN to meet TMMIN's production requirements (e.g. for quality, productivity and technology). In addition to providing machinery support, TMMIN also encouraged the SME to adopt technologies to improve efficiency and upgrade its factory.

CC Autopart (Thailand) is an SME producer of automotive and electrical appliance parts, industrial standard machinery and medical equipment. It supplies parts to Japanese manufacturers based in Thailand such as Kawasaki Motors, Kubota Precision Machinery, Toyota Tsusho and Yamaha Motor. CC Autoparts has invested in advanced manufacturing technologies such as automation and robots to meet the requirements of its customers and to expand into new product lines.[27] Another Thai SME, S.C.H. Industry, which manufactures disc brake pads, deployed the Toyota Production System to comply with the requirements of Toyota (Japan) and to streamline the production line. The SME also produce brake pads for Project Mu (Japan). It used Project Mu technology to produce a specific type of brake pads for Project Mu.

MNEs with Industry 4.0 technology programmes targeting digital transformation of ASEAN SMEs

Some MNEs support the digital transformation of SMEs in ASEAN. This can take two forms: (i) MNE-technology suppliers are present and create demonstration effects, and (ii) MNEs with Industry 4.0 technology packages adapt them for application to the SME's environment.

Having access to a growing pool of technology providers and an expanding digital ecosystem has led some SMEs to upgrade their factories or business operations. Close proximity to technology solution providers and demonstration effects can play a role in facilitating technology adoption by SMEs. For instance, *Crown Coffee* (Singapore) started as a traditional coffee shop and now has four shops operating with robotic technology, big data and AI solutions. Crown established Crown Digital to create a new retail ecosystem, harnessing the benefits of AI, machine learning, data analytics and automation technology. Crown Digital developed a fully automated coffee cart that operates 24/7, provides an interactive experience for customers and offers a remote maintenance warning system. It deployed technology from Techman (Taiwan Province of China) using collaborative robots, with a plug and play technology. Techman provides Crown with an after-sales service support system through its authorized distributors, such as Omron (Japan).

Kopi Kenangan (Indonesia) is a technology-enabled beverage retailer established in 2017 that has expanded to 400 stores in 26 cities. The SME has integrated its online and offline businesses, making use of on-demand services including Gojek (GoFood) and Grab (GrabFood) to extend its market reach. By the end of 2019, about one third of its transactions took place online. To meet the needs of its growing online businesses, it has received support from Alibaba Cloud (China) and benefited from Alibaba's cloud-based and data-driven solutions (e.g. big data analytics and third-party solutions integration). Funding from local and foreign venture capital companies has enabled the company to strengthen its operations in Indonesia, launch new products and invest in more technology.

United Sweethearts Garment (Malaysia) upgraded its production technology (hardware and software) and automated its manufacturing operations with assistance from MIDA's automation capital allowance and technology provided by MNEs. Automation has helped the SME reduce energy consumption, increase production output and decrease rates of defects. Automation machines were supplied by Gerber Technology (United States), linking with other technology suppliers, such as Adobe (United States) for software development, Alvanon (United States) for expertise in digital transformation of the the apparel business, Amazon Web Services (United States) for cloud computing services, Microsoft (United States) for a cloud platform, SAP (Germany) for enterprise application software and cloud services, Siemens (Germany) for industrial technology and SoftWear Automation (United States) for machine vision and robotics for textile companies.[28]

Messy Bessy Cleaners (Philippines) is a manufacturer of green and non-toxic household cleaning and personal care products. The SME adopted the Microsoft Dynamics (United States) Enterprise Resource Planning system, which helped streamline daily manual operations

and establish a cloud-based platform to house data on revenue sales, employee performance and supply chain procurement. As business expanded, traditional systems could not support operations because of the lag in relaying information. Adoption of the Microsoft technology has improved efficiency and provided Messy Bessy with an overall view of its daily operations (i.e. customers, sales and supply chain). The partnership with Microsoft also enabled the SME to deploy other digital solutions (e.g. data analytics and AI).

Some SMEs have started adopting Industry 4.0 technologies supplied by foreign technology providers operating in the region. These providers have specific technology programmes or packages that meet the need of SMEs and support them in their transformation (table 4.12). For example, Schneider Electric (France) installed IoT and connected automation technologies for a Singapore-based SME, Sanwa Group. Schneider has supported more than 50 SMEs in Singapore with technology transformation in their go-to-market operations and in their digitalization. Buhler (Switzerland), an industrial equipment manufacturer for the food and beverage industry, supplied and installed automation machines for Aalst, a chocolate factory in Singapore. About 90 per cent of the company's production process is automated and workers are needed only to pack products.[29] Buhler has also supplied industrial machine solutions to other SMEs such as coffee producer Kediri Inda in Indonesia and La Suerte Rice Mill in the Philippines.

Table 4.12. Technology providers targeting technology transformation by SMEs in ASEAN (Selected cases)

Company	Headquarters	Activity	Products/services to help SMEs adopt Industry 4.0 technology	Remarks
Innovo Robotics	United Kingdom	Robotic technology	Modular robotic arm	The company provides adaptable robotic solutions to fit SME needs, which are more diverse and in smaller production quantities than those of large factories.
Siemens	Germany	Industrial manufacturing products and solutions	Advance Manufacturing Transformation Centre	The Centre is a three-in-one facility in Singapore that supports digital transformation by manufacturing companies in ASEAN, including SMEs.
Schneider Electric	France	Energy and automation digital solutions	IoT platform Ecostruxure	Schneider provides "enterprise technology solutions" to help SMEs digitalize their operations.[b]
Omron	Japan	Electronics and industrial automation solutions	Robotic technology	Robots are helping businesses in various industries and SMEs in Singapore overcome challenges such as labour shortages and resource wastage.[c]

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Table 4.12. Technology providers targeting technology transformation by SMEs in ASEAN (Selected cases) (Concluded)

Company	Headquarters	Activity	Products/services to help SMEs adopt Industry 4.0 technology	Remarks
Microsoft	United States	Technology and software solutions	Microsoft BizSpark programme Microsoft Azure	Microsoft has been helping SMEs in ASEAN adopt new with technology. In the last five years in Singapore alone, it has connected with more than 100,000 SME customers through more than 1,000 business partners (i.e. authorized representatives, distributors), which are mostly local SMEs themselves. The company has supported about 1,400 start-ups in the region since 2008. It builds on Microsoft's Azure platform, data analytics, machine learning, AI and cloud computing solutions to support the transformation of SMEs in industries such as retail, logistics, and food and beverage.[a]
Huawei	China	Technology solutions and equipment	Industrial technologies such as the IIoT	Huawei provides support to boost digital transformation by SMEs in Malaysia. It has been helping in the development of the Malaysian SME ecosystem and assisting SMEs in their digital transformation.[d]
IBM	United States	Technology solutions and equipment	Cloud and AI services	IBM Thailand is pushing its AI, cybersecurity services and multi-cloud tech solutions to help SMEs in Thailand advance with digital transformation as they recover from the impact of the pandemic.[e]

Sources: Company websites, industry reports and media.
Note: AI = artificial intelligence, IoT = internet of things, IIoT = industrial internet of things, SMEs = small and medium-sized enterprises.
[a] Microsoft, "Empowering technology companies and SMEs in Singapore to seize opportunities in the digital economy", 3 November 2017.
[b] *Industrial Automation*, "Schneider digitising Southeast Asia's process automation" (https://www.iaasiaonline.com/digitising-southeast-asias-process-automation); Industrial-transformation.com, "Giants of industry inspire SMEs with strategic I4.0 solutions", 22-24 October 2019.
[c] Omron Asia-Pacific, "Robots as building blocks to SME success" (https://www.omron.asia/story/robots-as-building-blocks-to-sme-success).
[d] CEO of Huawei Technologies (M), "Accelerating Malaysian digital SMEs: escaping the computerization trap". (https://www.huawei.com/minisite/accelerating-malaysia-digital-smes/img/sme-corp-malaysia-huawei.pdf).
[e] *Techwire Asia*, "How IBM is boosting AI, automation for SMEs across Thailand", 16 July 2020.

Technology that enables SMEs to expand market reach and regionalize

A few ASEAN start-ups have grown to become unicorns (e.g. in Indonesia, GoJek and Tokopedia; in Singapore, Grab and Sea). They provide e-commerce and marketplace platforms, as well as other digital solutions (e.g. digital marketing, data analytics, AI, e-payment system and fintech) that enable other SMEs to digitalize (box 4.10).

These start-ups in turn partner with foreign technology companies to continuously upgrade technology to support the expansion of their digital services and products. They have received funding support for expansion from foreign and regional investors such as global tech companies, venture capitalists and investment houses (i.e. for technological infrastructure, both hardware and software, and for internationalization to other ASEAN countries and further afield).

Box 4.10. Role of technology start-ups in linking SMEs to digitalization

Some technology start-ups and companies are major conduits through which SMEs can adopt digital technologies because of their online platforms that enable SMEs to both source and market their products and services. These technology start-ups have connected with many technology MNEs to expand their businesses and to upgrade their digital technologies. Some have grown rapidly and are actively regionalizing their operations.

Tokopedia (Indonesia), now an e-commerce unicorn, partners with Alibaba Cloud (China) to enhance online shopping through adoption of a range of technology solutions, which include machine learning, AI and data storage. Tokopedia has also partnered with Mastercard (United States) to expand online payment choices. It has provided opportunities to many SMEs in the region to link up digitally and to expand their market reach. As of mid-2020, Tokopedia had about 8.3 million SMEs on its platform, most of them first-time entrepreneurs. The platform connects these small businesses with 90 million potential customers that visit the platform every month.[a] Although Tokopedia began with online sales of physical goods, it has expanded to other digital services such as flight and train booking, providing business opportunities to other SMEs in the region.

Grab (Singapore), which started as a ride-hailing platform, has expanded into a range of digital businesses including e-commerce, food and grocery orders and deliveries, express courier services, online payments, an insurance and investment platform, and hotel bookings. Grab has expanded regionally to Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The company links with many SMEs in ASEAN through providing them access to its various digital platforms. In Indonesia alone, an estimated 8 million-plus SMEs used its e-commerce platform in 2019.[b] Grab has established technology links with many MNEs. A strategic partner is Microsoft (United States); Grab uses the Microsoft Azure cloud platform and collaborates on other technology solutions such as big data, AI and machine learning.

Lazada, a subsidiary of Alibaba (China), is an e-commerce company with operations in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. It is headquartered in Singapore. Lazada is supported by Alibaba Cloud for technology solutions. Many SMEs in ASEAN use the Lazada platform for trading. In supporting SMEs in ASEAN, Lazada partners with Google (United States) to provide small online retailers with free training courses on digital skills and improving their online presence, especially during the pandemic.[c] It aims to assist 8 million e-commerce entrepreneurs and SMEs in ASEAN through its digital platform by 2030. It is also helping Lazada sellers create their own brands using its digital platform and facilitating transportation of goods in Southeast Asia with the company's own logistics network.

Sea (Singapore), a consumer internet company, has three core businesses, which cover e-commerce (through Shopee), digital entertainment (through Garena), and digital payments and financial services (through SeaMoney). In ASEAN, Shopee is present in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Tencent (China) has a substantive interest in Sea. Shopee has a strategic partnership with Visa (United States) to provide online shoppers and merchants with greater value, convenience and security through Visa.

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Box 4.10. Role of technology start-ups in linking SMEs to digitalization (Concluded)

The partnership focuses on (i) incentivizing MSMEs to digitalize their business on Shopee and adopt digital payments through Visa; (ii) providing MSMEs with marketing and campaign support to drive awareness, traffic and sales to online stores; (iii) launching co-branded credit cards in collaboration with local banks; (iv) offering fast, easy and secure Visa payments to all Shopee users; and (v) creating unique experiences for Shopee users through Visa's exclusive sponsorship platforms.[d] As of August 2017, there were 100 million listings in 20 categories and more than 3 million sellers on the Shopee platform (mostly SMEs).[e]

Sources: Company websites and media releases.
[a] *Jakarta Post,* "E-commerce brings in new entrepreneurs, expands market access in times of crisis", 16 July 2020.
[b] *Republika,* "Ministry, Grab Indonesia to encourage SMEs to go online", 13 April 2018.
[c] *SMEHorizon,* "Google and Lazada provide free digital skills training to online sellers", 5 November 2020.
[d] *Finextra,* "Shopee and Visa sign five-year strategic partnership", 1 October 2020.
[e] *The Straits Times,* "Whoppee, it's Shopee!", 28 August 2017.

Technology start-ups in ASEAN that scale up with regionalization

Some technology start-ups have successfully raised funds to scale up and to regionalize their operations (table 4.13). A few have become unicorns and have in turn invested in other strategic start-ups in the region. Examples include (i) Gojek (Indonesia) investing in Indonesian start-ups such as Halodoc, LinkAja, PasarPolis and Zulu; and (ii) Grab (Singapore) investing in LinkAja (Indonesia), Emtek Group (Indonesia), Ninja Van (Singapore) and Moca (Viet Nam). Other corporate venture capital firms are investing in start-ups. An example is Lazada, a subsidiary of Alibaba headquartered in Singapore, which is investing in iPrice Group, a start-up in Malaysia. In May 2021, PropertyGuru (Singapore) acquired REA Group's facilities in Malaysia (i.e. iProperty.com.my and Brickz.my in Malaysia) and Thailand (i.e. thinkofliving.com and Prakard.com).[30]

Table 4.13. ASEAN technology start-ups with a presence in other ASEAN Member States, 2021 (Selected cases)

Start-up	Activity	Headquarters	Regional expansion (selected locations)	Total funding (as of May 2021) ($ million)
Advance.AI	AI, big data, fintech, internet	Singapore	Indonesia, the Philippines, Viet Nam	136
Bigo Technology[a]	AI, internet, social media	Singapore	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, the Philippines, Thailand, Viet Nam	272
Carro	Automotive, e-commerce, marketplace	Singapore	Indonesia and Thailand	230
Carousell	Classifieds, consumer goods, e-commerce, marketplace, mobile apps	Singapore	Indonesia, Malaysia, the Philippines	178

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Table 4.13. ASEAN technology start-ups with a presence in other ASEAN Member States, 2021 (Selected cases) (Concluded)

Start-up	Activity	Headquarters	Regional expansion (selected locations)	Total funding (as of May 2021) ($ million)
Fave	Advertising platforms, digital marketing, e-commerce, digital merchant platform, mobile payment	Singapore	Indonesia, Malaysia	32
Glints	Employment, human resources, online portals	Singapore	Indonesia, Viet Nam	32
Grab	Transportation, financial services, food delivery, ride sharing, telemedicine	Singapore	Indonesia, Cambodia, Malaysia, Myanmar, the Philippines, Thailand, Viet Nam	12 148
Gojek	Consumer applications, food delivery, logistics, digital payment, transportation	Indonesia	Singapore, Thailand, Viet Nam	5 293
Holmusk	Analytics, biotechnology, electronic health record, personal health wellness	Singapore	Malaysia	..
Insider	Analytics, AI, big data, digital marketing, SaaS	Singapore	Indonesia, Malaysia, the Philippines, Thailand, Viet Nam	46
IPrice Group	Coupons, e-commerce, shopping	Malaysia	Indonesia, the Philippines, Singapore, Thailand, Viet Nam	21
Lazada	E-commerce, fashion, internet shopping	Singapore	Indonesia, Malaysia, the Philippines, Thailand, Viet Nam	4 210
Nium	Finance, financial services, fintech	Singapore	Indonesia, Malaysia	80
PropertyGuru	E-commerce, mobile apps, online portals, real estate	Singapore	Indonesia, Malaysia, Thailand, Viet Nam	536
QueQ	Apps, lifestyle, search engine	Thailand	Malaysia	3
Shopee	E-commerce	Singapore	Indonesia, Malaysia, the Philippines, Thailand, Viet Nam	..
Thunes	Financial services, fintech, mobile payments	Singapore	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Viet Nam	130
Traveloka	Travel, search engine, big data	Indonesia	Malaysia, Philippines, Singapore, Thailand, Viet Nam	1 170
Una Brands	E-commerce, retail	Singapore	Indonesia, Malaysia	40
Validus	Financial services, fintech, lending	Singapore	Indonesia, Viet Nam, Thailand	82
Zilingo	E-commerce, internet, mobile	Singapore	Cambodia, Indonesia, Philippines, Thailand, Viet Nam	308

Sources: ASEAN Investment Report 2020–2021 reserach, based on annex table 4.1, company websites and media reports.
[a] Parent company is YY Inc (China).

Digital start-ups

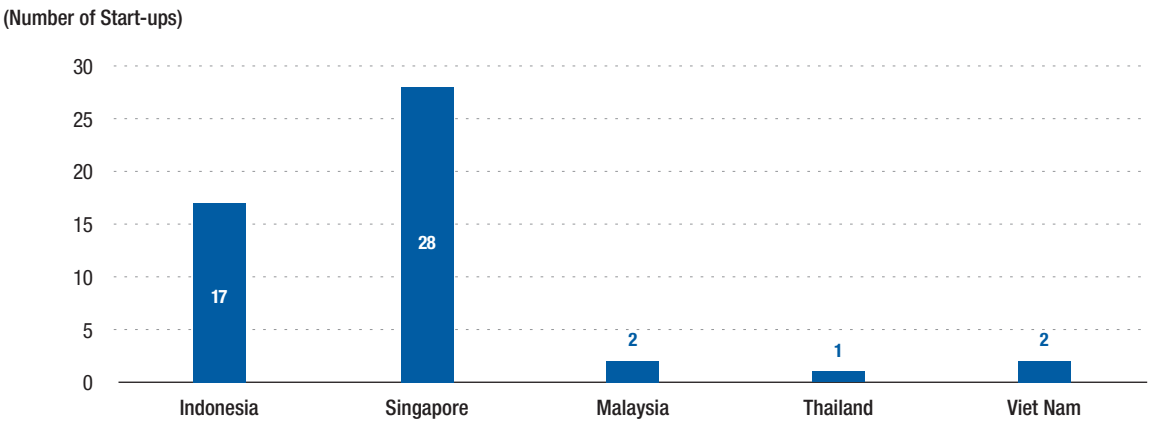
The rapid growth of the digital economy in ASEAN is a key driver for the increasing number of digital or tech start-ups, which are adding to the pool of SMEs and digital companies in the region. As of May 2021, there were more than 23,850 digital or tech start-ups across ASEAN (mostly in Singapore, Indonesia, Malaysia, Viet Nam, the Philippines and Thailand, in that order). That number reflects a 77 per cent rise, from 13,500, since August 2018 (*AIR 2018*). Singapore (39 per cent) and Indonesia (20 per cent) are the two largest concentrations of headquarters for the majority of start-ups in the region.

Top 50 start-ups

Despite the pandemic, start-ups in ASEAN raised about $8.2 billion in funding in 2020, which is about the same level as in 2019.[31] About 90 per cent of the top 50[32] are based in Singapore and Indonesia (figure 4.3). The ranking of the top 50 is based on Crunchbase algorithms that consider a combination of variables such as total funding amount, strength of relationships with other entities in the Crunchbase platform and the number of times the entity has been viewed in Crunchbase.

Singapore and Indonesia are significant locations for start-ups for different reasons and in different types of activities (table 4.14). The growth of start-ups in these countries in turn attracts venture capitalists and other investors. Start-ups favour Singapore because of its more developed financial infrastructure, conducive environment for fund-raising, status as a regional hub and high concentration of venture capital firms. Elsewhere, the market potential of Indonesia and the rapid growth of the digital economy there are attracting many start-ups, including those from neighbouring countries.

Figure 4.3. Top 50 start-ups in ASEAN, by nationality, 2021 (Number)



Source: Based on annex table 4.1.
Note: Top 50 ranked by Crunchbase based on algorithms that consider a combination of variables such as total funding amount, strength of relationships with other entities in the Crunchbase platform and the number of times the entity has been viewed in Crunchbase.

Table 4.14. Key characteristics of the top 50 start-ups headquartered in Indonesia and Singapore

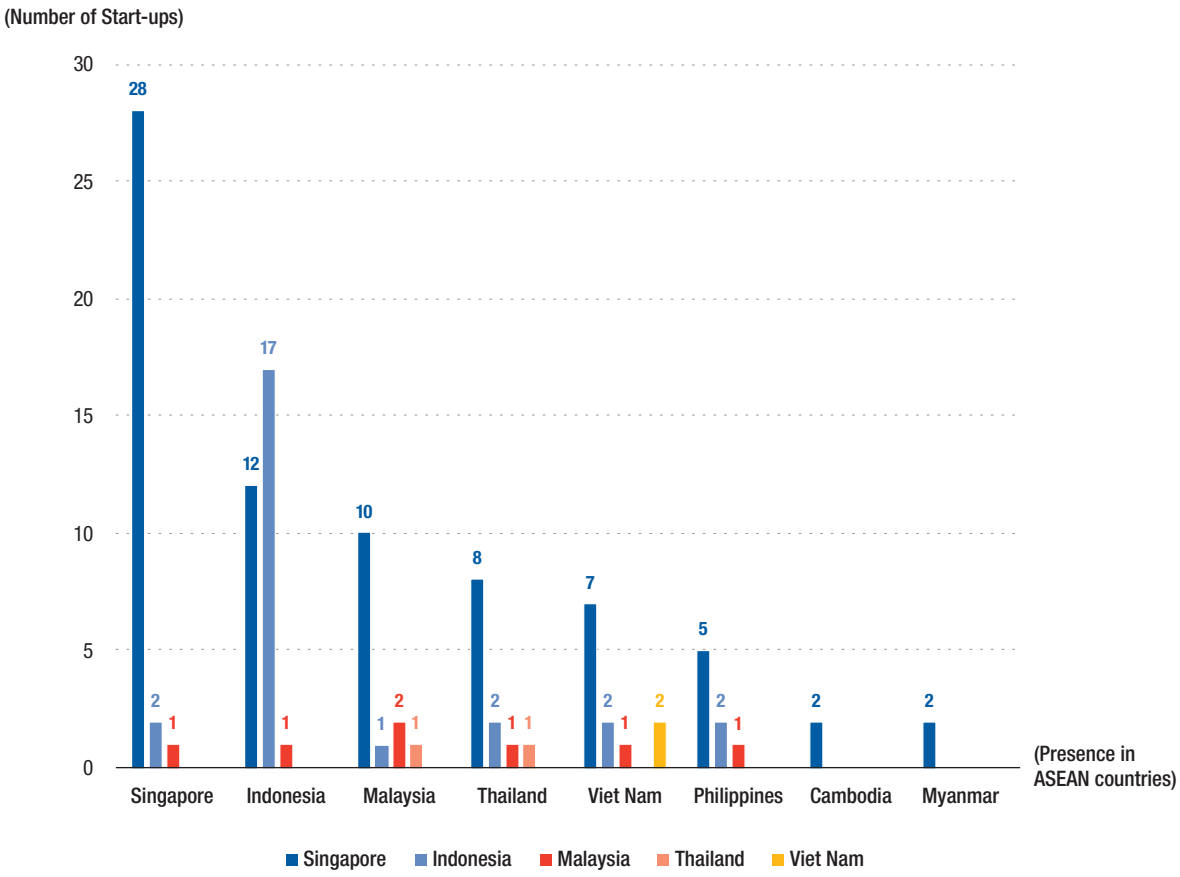
Characteristics	Indonesia start-ups	Singapore start-ups
Type of activities	Mostly market-oriented (such as e-commerce, food delivery, health technology, travel platform, fintech)	Market-oriented plus innovation and technology development (involving AI, machine learning, blockchain, industrial automation, robotics or biotechnology)
Market focus and key drivers	Mainly domestic market focused, with a few internationalized (e.g. within ASEAN) Important determinants: large market and growing digital economy	Majority with a presence in other ASEAN countries and further afield Key drivers: access to the country's financial system and the growing venture capital market Also influential: the more efficient digital and technology ecosystem
Nationality of venture capital firms (Five most popular)	United States, Singapore, Indonesia, China and India (in that order)	United States, European Union, Singapore, China and India (in that order)
Example start-ups	• Ajaib • Bukalapak • Bukukas • Bibit.Id • CoLearn • Gojek (unicorn) • Halodoc • LinkAja • TaniHub • Tokopedia (unicorn) • Traveloka (unicorn) • Ruangguru • Shipper • Sirclo • Xendi	• Carousell • Carro • Emeritus • Fave • Finlync • Glints • Grab (unicorn) • Hummingbird Bioscience • Moglix • Near • NextBillion.ai • Nium • Tribe Accelerator • Sea (unicorn) • StashAway

Sources: ASEAN Investment Report 2020–2021 research and annex table 4.1.

Indonesian start-ups operate mostly in e-commerce and marketplace platforms. A number of start-ups operate in healthtech (e.g. Halodoc), fintech and edutech (e.g. Ruangguru). More than 80 per cent of the top 50 focus on the country's large domestic market. Two Indonesian unicorns (i.e. Gojek and Traveloka) have expanded their operations and physical presence regionally. Tokopedia (another unicorn) is expanding domestically. In comparison, Singaporean start-ups are "born" regional or global. Their activities and products and services require them to internationalize because the domestic market is small. Singaporean start-ups in the top 50 include not only market-oriented entities but also many that build on or offer Industry 4.0 technology solutions to clients.

Among the ASEAN technology start-ups, those from Singapore are most regionalized, to countries such as Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Viet Nam (figure 4.4). Many from Singapore have also established a presence and networks in Indonesia because of that country's market size and potential. Malaysian start-ups (fintech and e-commerce) are also expanding regionally.

Figure 4.4. Regional presence of top 50 ASEAN start-ups, by host location, 2021 (Number)



Source: Based on annex table 4.1.

ASEAN and foreign venture capital firms supporting regionalization of technology start-ups in ASEAN

Venture capital, from both foreign entities and ASEAN ones, is an important source of support to the digital ecosystem. It provides early funding for start-ups and also funding that enables them to expand and internationalize (*AIR 2018*). Although the venture capital industry in ASEAN is still small compared with that in China and in the United States, opportunities in the region's digital industry are attracting more foreign venture capital and encouraging the expansion of ASEAN-based funds (i.e. intraregional investment). Investors includes both pure play and corporate venture capital firms, including ASEAN MNEs, as well as sovereign wealth funds (table 4.15).

Most venture capital funds investing in ASEAN start-ups across the region are based in Singapore. Some Singapore-headquartered venture capital firms invest solely in Indonesian start-ups (e.g. Falcon House Partners and Indies Capital Partners).

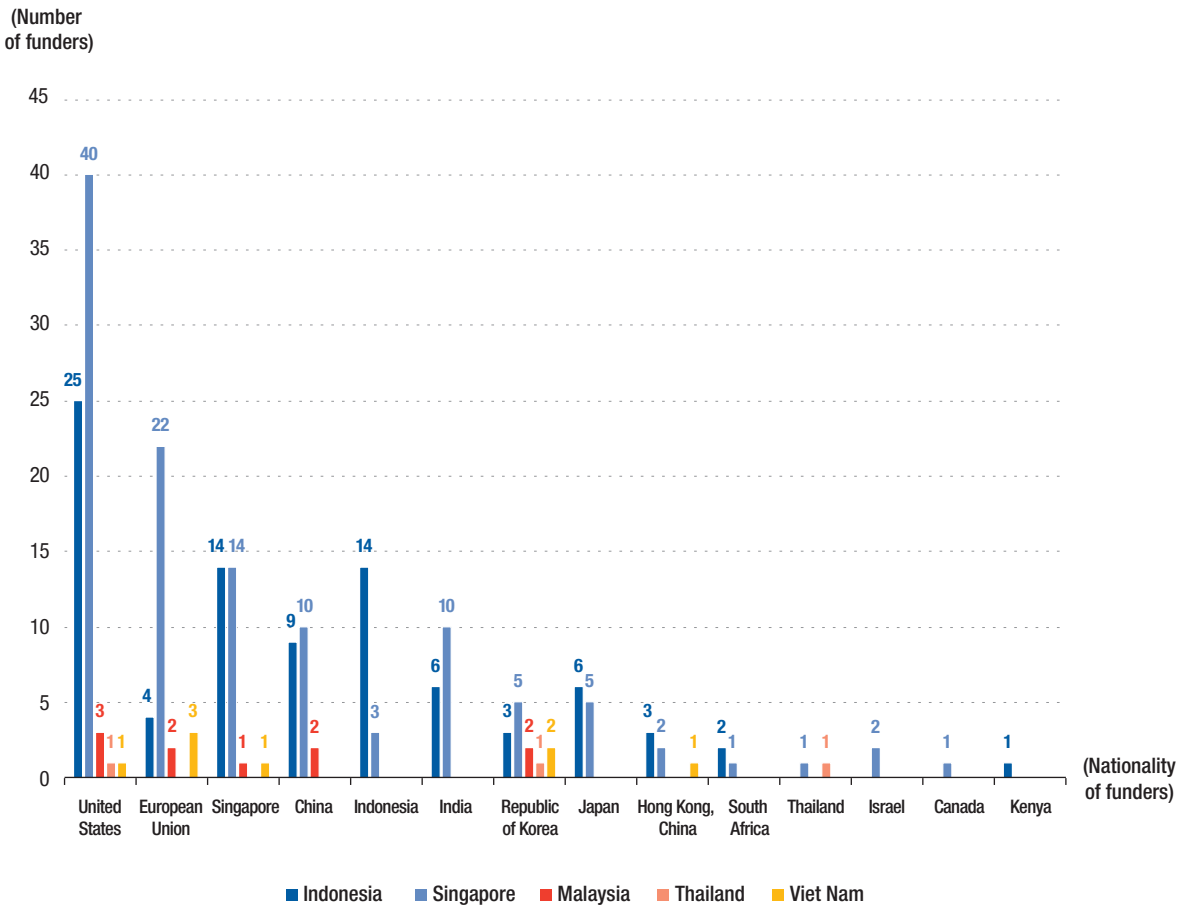
Table 4.15. ASEAN corporate venture capital firms investing in digital and technology start-ups in the region, 2021

Headquarters	VC	Parent company
Indonesia	MDI Ventures	Telkom Indonesia
	Sinarmas Land	Sinar Mas Group
	SMDV	Sinar Mas Group
	Skystar Capital	Skystar Ventures
	Emtek Group	PT Elang Mahkota Teknologi
	Mandiri Capital	Bank Mandiri
	PT Astra International	Astra Group
	Telkomsel	Telkom Indonesia
	BRI Ventures	Bank Rakyat Indonesia
	Venturra Capital	Lippo Group
Malaysia	IHH Healthcare	IHH and Khazanah Nasional
	Xeraya Capital	Khazanah Nasional
	Malaysia Venture Capital Management	Ministry of Finance
	Kumpulan Modal Perdana	Ministry of Finance
	Sun SEA Capital	Sunway Group
Philippines	Kickstart Ventures	Globe Telecom
	AdSpark Holdings	Globe Telecom
	PLDT Capital	PLDT
	IdeaSpace Foundation	Metro Pacific Investment Corp. (First Pacific)
	JG Digital Equity Ventures	JG Summit Group
	Agile Digital Ventures	Megaworld
Singapore	Temasek Holdings	Singapore Sovereign Wealth Fund
	SG Innovate	Government of Singapore
	EDB Investments	Economic Development Board
	Heritas Capital	IMC Group
	Singtel Innov8	Singapore Telecommunication
	UOB Ventures	United Overseas Bank
	Vertex Holdings	Temasek Holdings
	SPH Ventures	Singapore Press Holdings
Thailand	Addventures	Siam Cement Group
	True Incube	True Corporation
	SCB10X	Siam Commercial Bank
	Beacon Venture Capital	KasikornBank
	InVent	Intouch Holdings
	Krungsri Finnovate	Bank of Ayudhya (Krungsri Bank)

Sources: Crunchbase and *ASEAN Investment Report 2018*.

The international funders of the top 50 ASEAN start-ups are mainly from the United States, the European Union, China, India, the Republic of Korea and Japan, in that order (figure 4.5). ASEAN VCs (mostly from Singapore and Indonesia) are also actively investing in other start-ups in the region. Indonesian VCs tend to focus on Indonesian start-ups while Singapore-headquartered VCs spread their investments across start-ups in several ASEAN Member States.

Figure 4.5. Top 50 start-ups in ASEAN, by nationality of funders, 2021 (Number)



Source: Based on annex table 4.1.

(d) Challenges for transformation

SMEs can benefit from adopting digital technologies to improve productivity. Despite the benefits of Industry 4.0, SMEs face challenges in adopting technology, innovating and internationalizing (table 4.16). Key ones include the high cost of technology adoption, capital constraints, lack of knowledge in the application of technologies, lack of skills and skilled human resources, and concern about technology infrastructure, cybersecurity and data privacy (Ernst & Young, 2019; OUB, Accenture and Dun&Bradstreet 2020; GrabFinance and Bloomberg Media Studios, 2020).

Governments need to work with SMEs to support their digitalization and in Industry 4.0 transformation in both front-end and back-end operations. Governments should also help in building the capacity of SMEs to regionalize to connect ASEAN and realize the AEC goals for SME development.

Table 4.16. Challenges SMEs face in digitalization

	Challenges to Industry 4.0 technology adoption						
Name of survey	Lack of knowledge or understanding of application of technologies	Financial constraints	Credit guarantee	Lack of skilled human resources and technology skills capacity	Cybersecurity/ data privacy concerns	Existing digital infrastructure architecture	Increased competition, market demand changes
Ernst & Young 2019 SME Survey[a]	✓	✓	✓	✓	✓		✓
OUB, Accenture and Dun&Bradstreet 2020 SME Survey[b]	✓	✓	✓	✓		✓	✓
GrabFinance and Bloomberg Media Studios 2020 SME Survey[c]	✓	✓				✓	✓

Source: Respective surveys.
[a] Ernst & Young (2019). The survey covers six countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam).
[b] OUB, Accenture and Dun&Bradstreet (2020). The survey covers five countries (Indonesia, Malaysia, Singapore, Thailand and Viet Nam).
[c] GrabFinance and Bloomberg Media Studios (2020). The survey covers four countries (Malaysia, Singapore, the Philippines and Thailand).

(e) Policy options to support SMEs in Industry 4.0 transformation and internationalization

Many SMEs do not have the technological skills or know what is possible or how to apply Industry 4.0 technologies to upgrade their business operations. Limited capital and lack of access to finance are major funding challenges limiting their ability to adopt technology, and the lack of available skilled labour and access to concrete programmes for upskilling or reskilling are key human resource challenges to upgrading. Policymakers need to address these and other challenges hampering SMEs' adoption of technology and the bottlenecks that limit the capacity of technology SMEs to internationalize in order to grow. Some specific policy options for addressing these challenges appear in table 4.17. The number of SMEs going regional has remained small despite the benefits of the AEC, which provides a large regional market and opportunities to tap different locational advantages. Reasons for this small number include lack of information on investment opportunities, fear of the unknown in or additional risks associated with venturing across national boundaries, and lack of access to funding for internationalization.

Table 4.17. Specific policy options for promotion of Industry 4.0 to SMEs in ASEAN

Challenge	Policy option	Specific actions
Limited technology ecosystem	Strengthen the technology ecosystem for SMEs	1. Support SMEs in upgrading technology, innovating and developing related supporting industries to improve the efficiency of the technology ecosystem in the region. 2. Support and encourage SMEs in manufacturing parts and components used in Industry 4.0 equipment (e.g. motors, sensors, precision machinery).
Lack of knowledge in application of Industry 4.0 technologies	Strengthen Industry 4.0 technology capacity-building and absorptive capacity so that SMEs can adopt, innovate and manufacture equipment	1. Promote collaboration between Industry 4.0 technology providers (MNEs), SME associations and national SME agencies in building capacity for technology adoption, understanding the relationship between technology and industrial upgrading, and identifying key areas for development by SMEs in supporting industries for Industry 4.0. 2. Attract MNEs in Industry 4.0 to establish training centres, centres of excellence and Industry 4.0 courses, specifically designed for SMEs. 3. Incentivize MNEs to develop a dedicated Industry 4.0 transformation programme suitable for SMEs (e.g. offer bite-size technology packages or solutions for SMEs). 4. Institutionalize incentive programmes to support SMEs in upgrading technology and adopting Industry 4.0 technology. Establish funds or grants and technical support for SMEs to invest in Industry 4.0 technologies. 5. Create SME-dedicated "sandboxes" where Industry 4.0 technology providers, domestic systems integrators and SMEs participate. This can help policymakers gain insights into the process of how SMEs look at technologies and challenges with regard to funding partnerships. 6. Establish mentorship or peer influence programmes for ASEAN SMEs to learn from foreign SMEs located in ASEAN on their path to Industry 4.0 transformation and internationalization.
Financial constraints and access to finance	Develop a support environment to help SMEs adopt technology through access to finance and raising funds for internationalization	1. Establish a regional platform for venture capitalists and technology SMEs and start-ups for networking and for fund-raising, including for internationalization. 2. Establish a region-wide system for cross-border funding aimed at technology SMEs.
Lack of skilled labour and employees for Industry 4.0	Establish an ASEAN-wide labour pool for Industry 4.0 technologies	1. Establish Industry 4.0 skill centres for SMEs involving public-private partnerships with participation by MNEs. 2. Foster collaboration between foreign Industry 4.0 technology providers and centres of excellence, as well as technology and technical centres in the region to conduct training programmes and workshops for SMEs based in ASEAN. 3. Incentivize Industry 4.0 technology providers to establish dedicated SME training programmes and courses for upskilling or reskilling. 4. Promote MNE–academia partnership in Industry 4.0 skills development, targeting SMEs. 5. Establish an ASEAN-wide mutual recognition of Industry 4.0 skills to support the movement of skilled workers across ASEAN at targeted levels of technology employment.
Internationalization or regionalization of technology SMEs	Support SMEs in internationalizing to strengthen competitiveness, regional integration, AEC goals and access to overseas markets, including skilled human resources and know-how for technology innovation	1. Strengthen SMEs' capacity to internationalize with programmes, workshops and coaching. 2. Provide information on the regional market and investment opportunities through collaboration between investment promotion agencies and SME agencies in the region. 3. Establish platforms with relevant stakeholders for fund-raising by SMEs for expanding their regionalization. 4. Foster match-making between ASEAN technology SMEs to facilitate joint ventures involving cross-border SME and MNE production activities in Industry 4.0.

Source: ASEAN Investment Report 2020–2021 research.

4.5. POLICY OPTIONS AND WAYS FORWARD

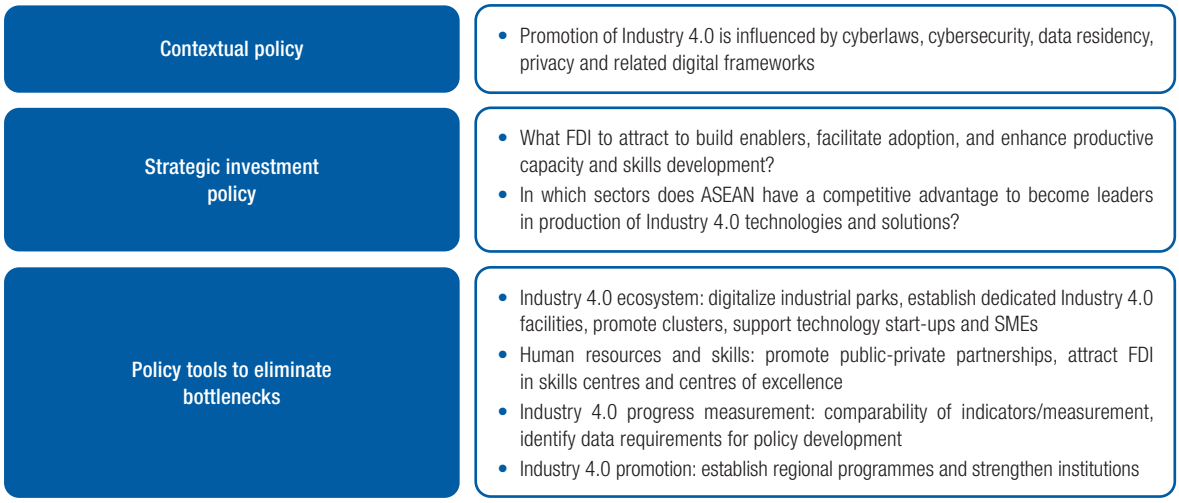
Policies to attract FDI in Industry 4.0 can be grouped into three categories (figure 4.6):

(i) at the contextual level; cyberlaws, cybersecurity, data protection and privacy, and data residency are important factors determining the attractiveness of the investment environment in Industry 4.0 relevant sectors;

(ii) setting strategic investment policy direction to support ASEAN in attracting FDI to build enablers and improve productive capacity, which underpins Industry 4.0 transformation. These include questions such as what FDI to attract to build digital infrastructure enablers and in which Industry 4.0 equipment and solutions manufacturing sectors do ASEAN and individual ASEAN members have a competitive advantage to become leaders. The investment chapter of Industry 4.0 action plans could address such strategic questions and IPAs be provided with policy guidance for implementation; and

(iii) specific policy measures to address bottlenecks that impede Industry 4.0 transformation should target at strengthening the capacity of Member States to attract FDI in relevant industries and activities. This level of policy options is the main focus of this report.

Figure 4.6. A framework for policy options



Source: ASEAN Investment Report 2020–2021 research.

4.5.1. Policy options to address bottlenecks

These policy options can be categorized as strengthening the Industry 4.0 ecosystem and facilitating investment, incentivizing SMEs and attracting FDI by them, regulating and promoting innovation, developing skills and building capacity, establishing an Industry 4.0 skills development and training centre, measuring Industry 4.0 development, promoting Industry 4.0, supporting sustainable digital development and strengthening regional institutions for Industry 4.0.

(a) Strengthening the Industry 4.0 ecosystem

To help develop the Industry 4.0 ecosystem, actions in the following areas could be considered:

(i) Attracting FDI to build digital infrastructure (5G, hyperscale broadband, data centres)

(ii) Attracting investment in production of digital and Industry 4.0 machinery, equipment, parts and components, technology solutions and supporting industries through targeted policies

(iii) Promoting public-private partnership in development of Industry 4.0 industrial infrastructure (e.g. Singapore's public-private partnership initiative with investment in different industrial parks in ASEAN (chapter 1) and Industry 4.0 clusters

(iv) Attracting investment in knowledge and technology-oriented R&D hubs and centres of excellence

(v) Promoting regionalization of technology SMEs through the following programmes:

- Regional mentorship programme on "going regional", including promoting regional investment opportunities to technology SMEs
- Regional and national workshops on the use and application of Industry 4.0 technologies
- Investment guidebooks for undertaking intra-ASEAN investment for technology SMEs

(b) Facilitating investment

Policymakers have several options for upgrading selected industrial parks to target them more specifically towards attracting FDI in Industry 4.0-relevant activities. Traditional industrial parks or special economic zones (SEZs) may not be equipped to support Industry 4.0 factories because of the lack of digital infrastructure (such as 5G networks and hyperscale broadband). SEZ authorities in some Member States are partnering with the private sector to upgrade industrial parks or to digitalize industrial parks to make them suitable for Industry 4.0 activities (box 4.11). To facilitate FDI in Industry 4.0 activities, some Member States are building dedicated industrial facilities to develop Industry 4.0 clusters. One example is Singapore Jurong Town Corporation, with the Jurong Innovation Park and the ARTC (see box 4.3).

ASEAN Member States that aim to attract FDI in Industry 4.0 could promote upgrading of selected industrial parks or developing smart industrial parks with Industry 4.0-ready facilities and efficient digital infrastructure. The parks could be selected by identifying industries or clusters that Member States are successful at attracting (e.g. clusters of automotive and electronics industries). More industrialized Member States could consider developing dedicated Industry 4.0 parks or facilities to attract Industry 4.0 clusters and related institutions (e.g. science and technology centres, centres of excellence, R&D centres and major anchor tenants) to strengthen the ecosystem.

Box 4.11. Upgrading industrial parks to attract Industry 4.0 clients

Thailand is developing smart industrial estates and smart cities, with government agencies partnering with local and foreign companies in the process. The Industrial Estate Authority of Thailand (IEAT) and PTT (Thailand) are involved in a joint initiative to digitalize factories in industrial estates in the country.[a] The initiative is expected to include the provision of digital solutions to upgrade factories, including by applying robotics and automation. Participating companies or factories will be given advice and guidelines on how to apply robotics and automation to their businesses and ways to develop more environmentally friendly operations.

In addition, the IEAT is developing a smart industrial park in Rayong Province, the Ministry of Digital Economy and Society is developing the Eastern Economic Corridor Digital Innovation Zone, the Ministry of Science and Technology is partnering with PTT (Thailand) to develop an Eastern Economic Corridor of Innovation, and Amata (Thailand) is working on transforming its industrial estates into smart cities. Amata is partnering with Yokohama Urban Solution Alliance (Japan) to develop a smart city plan and cooperated with Hitachi (Japan) to establish the Lumada Center for smart manufacturing development. The IEAT and the State-owned Telecom of Thailand are developing digital infrastructure.

Smart industrial estates and smart city developments are promoted by the Government under the country's smart city development plan. The plan aims to develop 10 smart cities initially and a total of 100 in the following five years. Investment incentives are provided to investors for the development of smart industrial estates and smart cities.

Sources: Media and Siam Commercial Bank.
[a] *Bangkok Post,* "PTT, IEAT join hands to study plan to digitalise factories", 18 May 2021.

(c) Incentivizing SMEs and attracting FDI by SMEs

SMEs form an important part of the Industry 4.0 ecosystem. ASEAN and foreign SMEs constitute a large pool of firms in ASEAN. Increasing their adoption of Industry 4.0 technology will increase demand for such solutions and hardware, which will encourage more market-seeking FDI in Industry 4.0. SMEs could play a role in developing the Industry 4.0 supporting industry through investment, including strengthening linkages with MNEs.

In expanding the role of SMEs in the development of Industry 4.0 ecosystems, policies could be targeted to attract FDI by SMEs in (i) producing Industry 4.0 solutions and equipment, including parts and components, and (ii) promoting regionalization of technology SMEs, including joint venture operations between foreign SMEs and local SMEs, and between MNEs and local SMEs. Other policy options could aim to support technology SMEs in innovating and developing Industry 4.0 activities and regionalizing their operations in ASEAN.

Member States are putting in place concrete national measures to help SMEs transition and take advantage of digital technologies to grow. At the regional level, a dedicated annual forum for SMEs to discuss intraregional cooperation on overcoming challenges and bottlenecks that hamper investing in Industry 4.0 activities could be considered. A regular dialogue

between SME representatives, the ASEAN Investment Area (AIA) Ministers and the ASEAN Digital Ministers could be considered. The forum could also provide a platform to share experiences and to strengthen cross-border cooperation on digital transformation matters. Specific policy options to support the development of technology start-ups and SMEs, including their internationalization, are covered in section 4.4.3.

A series of documents that capture key or inspiring stories of FDI by SMEs in Industry 4.0 activities could be useful to motivate SMEs to move towards digital transition and internationalization:

(i) Prominent cases of business linkages between MNEs and SMEs in Industry 4.0 transformation

(ii) Best practices in and success stories of Industry 4.0 transformation, from the SME perspective, which could include SMEs and start-ups involved with Industry 4.0 activities as investors, solution providers, vendors, innovators and ecosystem contributors

(iii) Information booklets on coaching, financial support and capacity-building in adopting Industry 4.0 technologies to improve efficiency and investing in Industry 4.0-related sectors in ASEAN

(d) Regulating and promoting innovation

Member States could consider balancing necessary regulation with promotion of innovation. This would include regulating areas such as cybersecurity and data protection to ensure the integrity of the digital system and to prevent cybercrime. In a digital data environment, policymakers need to consider issues of data ownership, data residency and data security so as to protect users (e.g. in e-commerce, data storage and cloud services). Overregulating could impede the innovation required to advance the development of Industry 4.0 (e.g. the IIoT, big data, data centres), which could stifle investment. ASEAN's existing cooperation on cybersecurity and data protection could move forward with a regionwide system, protocols, exchanges of experiences and standard setting that protects consumers and also promotes innovation

(e) Developing skills and building capacity

The lack of skilled human resources for Industry 4.0 transformation remains a major challenge across the region (A.T. Kearney and WEF, 2018 and Ernst and Young, 2019). In advancing, it is crucial to address this skill gap. A number of initiatives involving the participation of MNEs could be considered:

(i) Attracting FDI in Industry 4.0 skills development centres, universities for Industry 4.0 and involving MNEs in conducting Industry 4.0 training or sharing of experiences. MNEs could be encouraged to participate in conducting Industry 4.0 courses of local universities or technical institutions. MNEs can be an effective catalyst for upskilling and reskilling as they bring different expertise, experiences, practical insights and knowledge on technology application to industry.

(ii) Emulating successful partnership programmes between public institutions and MNEs in training and skills development, as have taken place in some Member States.

(iii) Establishing dedicated Industry 4.0 skills and resource centres under public-private partnership arrangements with the participation of MNEs.

(iv) Incentivizing MNEs to establish centres of excellence and innovation hubs, including developing purpose-built technology centres or parks equipped with Industry 4.0 infrastructure and connectivity.

(f) Establishing an ASEAN Industry 4.0 skills development and resource centre

A regional Industry 4.0 skills development and resource centre could be considered. The objective would be to provide a platform for regular discussion and exchange of best practices on skills needed for Industry 4.0 transformation across the region. The centre could offer "training of trainer" programmes and involve regional and international experts in the training. By liaising and cooperating closely with relevant national skills centres and regional industry associations, it could be a regional focal point for skills development for Industry 4.0. It could establish a network of skills and training centres involving MNEs' participation and public-private partnership arrangements.

A significant role of this regional centre could be to provide regular policy input to support the ASEAN Human Resources Development Ministerial Meeting and the ASEAN Digital Ministers Meeting. Such input could focus on the skills and talent development to support Industry 4.0 transformation in the region.

(g) Measuring Industry 4.0 development

Supporting regional cooperation in measurement of progress on Industry 4.0 could be considered. Definitions of Industry 4.0 benchmarks vary across the region. Member States use different indicators and thresholds in measuring Industry 4.0 development by firms. For instance, no common definition exists for smart factories, and the indicators used to identify smart factories are not the same across countries. Although some Member States use an index to measure Industry 4.0 readiness, the measurement systems are not all the same (table 4.18). The lack of a common and comparable measurement system could constrain understanding of Industry 4.0 development and how MNEs and local companies have played or could play a role in the transformation process in the region. It could also limit regional capacity to identify policies that can advance cooperation in facilitating investment in Industry 4.0.

FDI data reported regionally in relation to Industry 4.0 are limited, hampering understanding of the FDI trend and the role of MNEs in the transformation. Strengthening regional cooperation in FDI data requirements to support policy development for attracting investment in Industry 4.0 could be considered.

Table 4.18. Industry 4.0 readiness index in ASEAN

Country	Title of index	Areas for assessment
Indonesia	INDI 4.0 Readiness Index	• Management and organizational • People and culture • Products and services • Technology • production processes/factory operation

Malaysia	Industry4ward Readiness Assessment	• Stage of a company's Industry 4.0 transformation journey
		• Type of technology adopted, which include for
		  ○ Inventory
		  ○ Digital
		  ○ Administration
		  ○ Information and internet security
		  ○ Marketing and communication
		  ○ R&D and design
		• Level of automation
		• System employed for operations, process, machine maintenance, connectivity, training and productivity management

Philippines	(Smart Industry Readiness Index) In development	In development

Singapore	Smart Industry Readiness Index	• Process
		  ○ Operations (Vertical Integration)
		  ○ Supply Chain (Horizontal Integration)
		  ○ Product Lifecycle (Integrated Product Lifecycle)
		• Technology
		  ○ Automation (Shopfloor, Enterprise, Facility)
		  ○ Connectivity (Shopfloor, Enterprise, Facility)
		  ○ Intelligence (Shopfloor, Enterprise, Facility)
		• Organization
		  ○ Talent Readiness (Workforce Learning & Development, Leadership Competency, Inter-and Intra-Company Collaboration, Strategy & Governance)
		  ○ Structure & Management (Workforce Learning & Development, Leadership Competency, Inter-and Intra-Company Collaboration, Strategy & Governance)

Thailand	In development	In development
Viet Nam	In development	In development

Sources: Respective government's website.

(h) Regional promotion initiative

In the past three years, ASEAN Member States have adopted many agreements and measures at both national and regional levels to promote Industry 4.0 transformation. This important information is not located in one place. It would be helpful and effective to offer prospective investors a consolidated document of major agreements, measures and Industry 4.0 plans as an effort to promote FDI in Industry 4.0 in the region. Regulations and promotion measures for investment in Industry 4.0-relevant activities are significantly different from general investment policies. Therefore, it would also be useful to provide a list of related regional and national institutions to which investors could turn for information or support regarding investment

in Industry 4.0 activities. The document could be updated periodically to provide investors with the latest information on the development of the Industry 4.0 ecosystem in the region. It could be hosted at the websites of the ASEAN Secretariat and of individual Member States.

(i) Supporting sustainable digital development

In supporting sustainable development goals, a regional framework or agreement could be adopted to base digital development on sustainable practice. For instance, data centres consume significant electricity to power their operation, and recent years have witnessed a surge in the number of such centres in the region. ASEAN could adopt a regional protocol on the promotion of green data centres and of operation using renewable energy. ASEAN could also promote smart industrial parks across the region, aligned with promotion of green or renewable energy technology.

(j) Strengthening regional institutions for Industry 4.0

Regional institutions could be further strengthened by expanding their roles to include identifying and discussing investment policy issues to attract FDI in Industry 4.0. One such mechanism could be regular joint meetings of the ASEAN Coordinating Committee on Investments and the ASEAN e-Commerce Committee with an ASEAN body for Industry 4.0 transformation, and between the ASEAN Investment Area Ministerial Council and the ASEAN Digital Ministers.

The regular meetings referred to here could consider task forces to deal with identifying policy measures that could further strengthen private investment in (i) industrial automation, robots and additive manufacturing application; (ii) connected technologies, which include the IIoT and smart factories; and (iii) assessment of Industry 4.0 implications and the mitigating impact of Industry 4.0 transformation.

Private sector engagement

It is important to understand the role of MNEs and the extent to which they participate in and contribute to Industry 4.0 transformation in ASEAN. A regular public-private sector forum on Industry 4.0 technologies and on approaches to attract related FDI to build a conducive ecosystem could be a useful channel for regional policy development. An ASEAN Industry 4.0 transformation advisory council could also be considered. The council could be encouraged to provide inputs to advance Industry 4.0 transformation and to hold an annual Industry 4.0 “state of play” dialogue forum with AIA Ministers and ASEAN Digital Ministers or other relevant senior ASEAN bodies. The council could include leading corporations in Industry 4.0 technologies covering such areas as digital infrastructure (5G and data centres), industrial automation and robots, additive manufacturing, connected technologies and the IIoT, and smart factories.

4.6. CONCLUSION

ASEAN Member States are actively promoting the adoption of Industry 4.0 technologies to improve manufacturing efficiency and productivity, and to benefit from this industrial revolution. Industry 4.0 can further boost the region's manufacturing potential, upgrade industrial development, improve ASEAN's attractiveness for international production and support upgrading in global value chains. All of these aspects underscore the importance in attracting FDI in Industry 4.0 and harnessing the role of MNEs and SMEs.

Many Member States have adopted or are adopting national plans for Industry 4.0 transformation. Their efforts in promoting adoption of Industry 4.0 technologies by industries can enhance the development of the digital ecosystem – an important determinant for attracting FDI. Most Member States have also adopted specific measures to attract FDI in Industry 4.0, which include offering investment incentives and providing institutional support. In some cases, they have established dedicated industrial facilities to develop Industry 4.0 clusters and facilitated linkages with public R&D centres, universities and innovation hubs.

Industry 4.0 transformation in ASEAN is at a nascent stage, and progress differs markedly between Member States. Rising manufacturing vibrancy has helped some Member States attract FDI related to Industry 4.0, encouraged by the growing pool of manufacturers, the prospects for imminent technology adoption and the growing digital economy.

There is an important symbiotic relationship between Industry 4.0 and the FDI environment. They reinforce each other for attracting FDI. Digital adoption can improve the efficiency of the investment and manufacturing environment, which can increase the attractiveness of the region for FDI. The improving investment environment in turn can help attract FDI in Industry 4.0 related activities. Industry 4.0 offers opportunities to attract new types of investment in relevant industries; however, it can also have an impact on traditional labour-intensive FDI as operations become autonomously driven, smart and digitalized, replacing labour.

Although MNEs are important actors in the Industry 4.0 transformation (e.g. as investors, technology solution providers, manufacturers and supporting skills and capacity-building), SMEs can play a role in the development of supporting industries and potentially offer a large pool of customers for Industry 4.0 transformation (contributing to the demand-pull environment). Significant linkages in SME internationalization involve digital technology: MNE-SME vendor relationships in technology upgrading, technology that enables SMEs to expand their market reach and regionalize, technology start-ups in ASEAN that scale up with regionalization, and ASEAN and foreign venture capital firms supporting regionalization of technology start-ups in the region.

Supporting Industry 4.0 transformation and internationalization by SMEs is important, as they face greater challenges on these fronts. Specific measures could include building capacity, addressing bottlenecks and adopting national and regional policy options for encouraging technology SMEs to internationalize or invest in ASEAN. Policies could be targeted to attract FDI by SMEs in production of Industry 4.0 solutions and equipment, including parts and components; by encouraging technology SMEs to innovate and get involved with activities

related to Industry 4.0 (supporting industry development); by promoting regionalization of technology SMEs, including joint ventures between foreign SMEs and local SMEs, and between MNEs and local SMEs; and to address bottlenecks and challenges that constrain SMEs in adopting technology and internationalizing (i.e. lack of understanding of technology application and the lack of knowledge or information for internationalization).

The challenges in attracting FDI in Industry 4.0 stem from the current limited (but growing) market opportunities for adoption of hardware and technology solutions. The absence of an efficient digital ecosystem (in some cases), the lack of skilled human resources and the lack of digital infrastructure limit the ability of countries to attract FDI related to Industry 4.0.

To attract FDI, these challenges need to be addressed. ASEAN Member States could consider strengthening the national and regional digital ecosystem to provide an efficient investment environment, attracting clusters of different categories of players and promoting public-private partnerships (involving MNEs) in the upskilling and reskilling to support the transformation. ASEAN Member States could facilitate FDI in Industry 4.0 by developing or upgrading selected industrial parks and promote sustainable digital development with green energy.

An increasing number of manufacturers are recognizing the potential benefits of digitalization and more are planning to adopt such technologies. The expanding manufacturing base and the increasing interest of firms in adopting Industry 4.0 technologies are attracting more attention from Industry 4.0 related businesses looking to invest and establish a presence in the region – on top of those already operating in ASEAN. As such, the prospects for FDI in Industry 4.0 are promising for both new and expansion activities.

This chapter has presented FDI policy options at three levels; namely at the contextual level, strategic investment policy direction and measures to address the bottlenecks. Regional cooperation efforts in ASEAN are essential at all three levels.

NOTES

[1] The other four priority clusters are halal projects (e.g. pharmaceutical and health supplements, food processing), business services (e.g. transportation and logistics, business process outsourcing), downstream oil and gas, and tourism.

[2] Council for the Development of Cambodia, "Investment opportunities and priority sector", http://www.cambodiainvestment.gov.kh/why-invest-in-cambodia/investment-opportunities-and-priority-sector.html.

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[5] Malaysia Government Portal, "Capacities for Digital Transformation" (https://www.malaysia.gov.my/portal/content/30734).

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[14] *Febis*, "VietnamCredit: New investment incentives for foreign investors in Vietnam", 29 September 2020".

[15] *Bloomberg*, "Tax incentives for supporting industries in Viet Nam", 29 December 2020.

[16] Some of the guiding documents on these issues include the AEC Blueprint 2025, ASEAN E-Commerce Agreement, ASEAN Digital Integration Action Plan 2019–2025, and ASEAN Digital Masterplan 2025.

[17] The guiding documents on these issues include the AEC Blueprint 2025, 2016 ASEAN Framework on Personal Data Protection, ASEAN e-commerce agreement, ASEAN Digital Masterplan 2025 and ASEAN Declaration on Industrial Transformation to Industry 4.0.

[18] The 26 pilot cities are Bandar Seri Begawan, Battambang, Phnom Penh, Siem Reap, Makassar, Banyuwangi, DKI Jakarta, Luang Prabang, Vientiane, Johor Bahru, Kuala Lumpur, Kota Kinabalu, Kuching, Nay Pyi Taw, Mandalay, Yangon, Cebu City, Davao City, Manila, Singapore, Bangkok, Chonburi, Phuket, Da Nang, Hanoi and Ho Chi Minh City.

[19] These issues are covered by regional action plans and agreements such as the AEC Blueprint 2025, the AEC 2025 Consolidated Strategic Action Plan, the ASEAN Digital Integration Framework Action Plan 2019–2025, the E-Commerce Agreement and its Work Programme (2017–2025).

[20] See regional documents such as the 2020 ASEAN Declaration on Human Resources Development for the Changing World of Work and ASEAN Declaration on Industrial Transformation to Industry 4.0.

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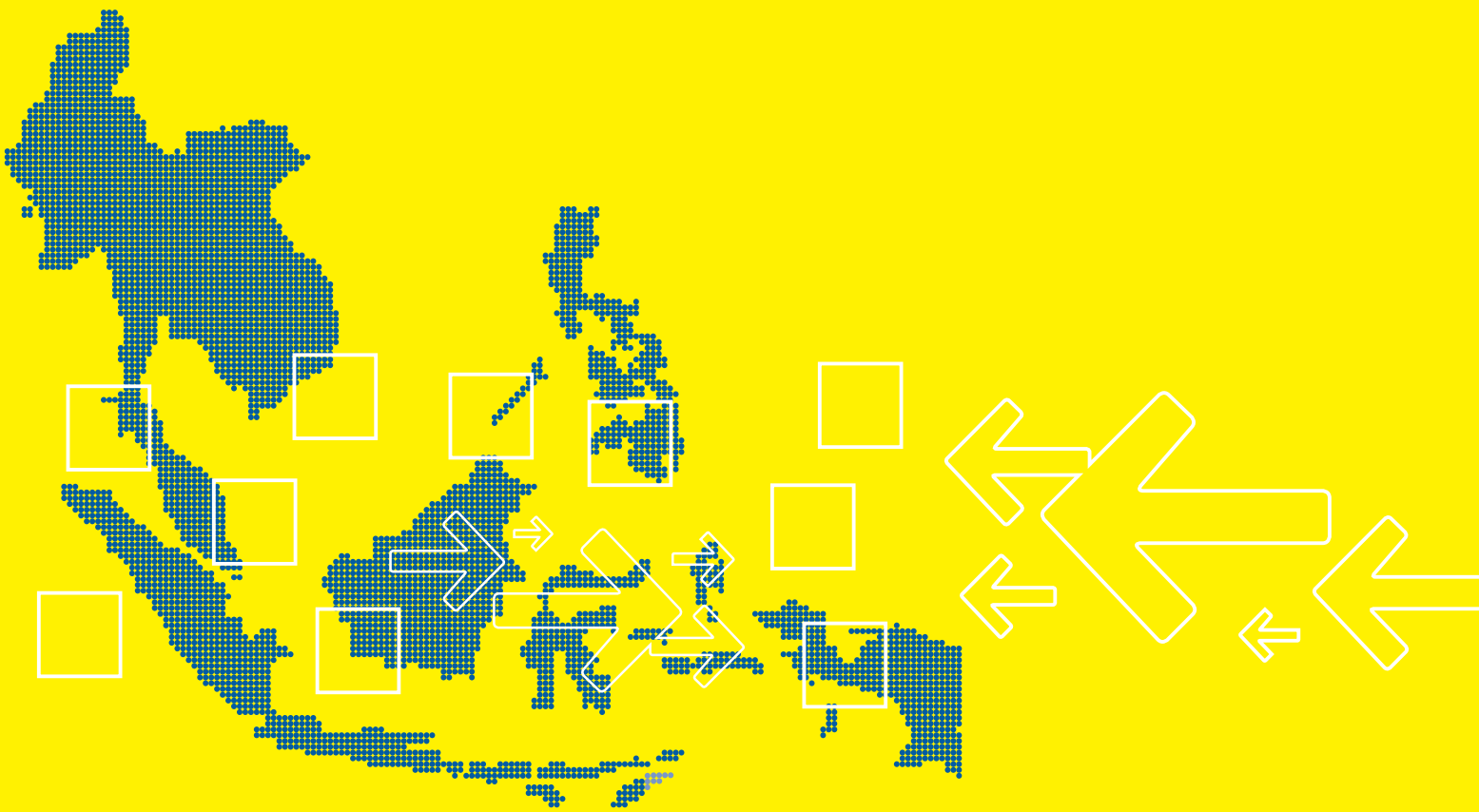

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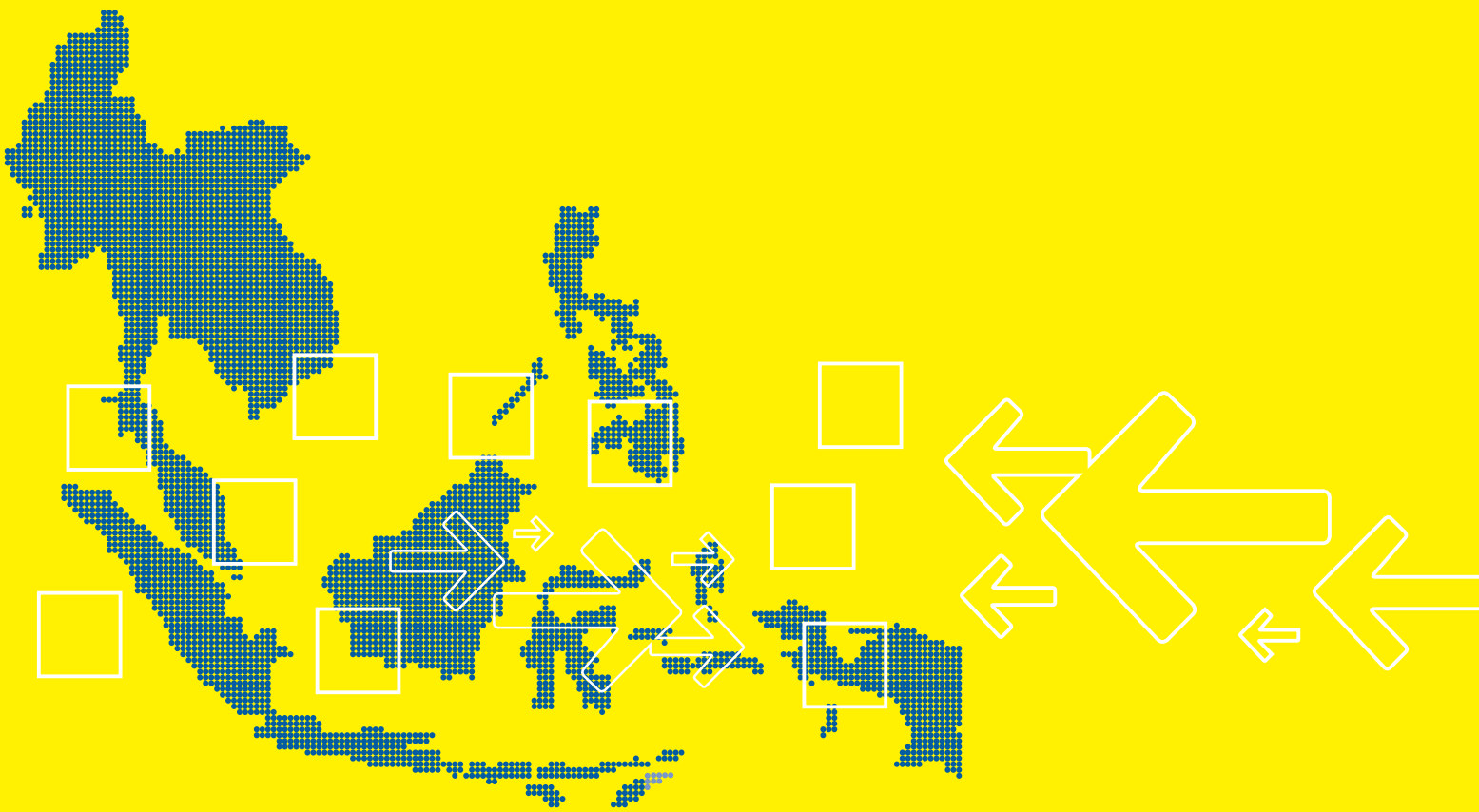
ANNEXES



Annex table 1.1. The 100 largest MNEs from non-ASEAN RCEP countries in ASEAN, by total assets, 2020

	MNE	Headquarters	Industry/activity	Cash and cash equivalent, 2020[a] ($ million)	Total assets, 2020[a] ($ million)	ASEAN countries with subsidiaries
1	CITIC Group	China	Business services	n.a.	1 071 530	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand
2	China National Petroleum	China	Chemicals, petroleum, rubber and plastic	33 665	606 232	Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
3	State Grid Corporation of China	China	Utilities	10 329	594 798	Indonesia, Malaysia, Philippines, Singapore
4	Toyota Motor	Japan	Transport manufacturing	44 795	484 641	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
5	Petrochina	China	Mining and extraction	15 839	391 142	Singapore, Thailand
6	Softbank Group	Japan	Media and broadcasting	31 512	342 753	Cambodia, Indonesia, Malaysia, Myanmar, Singapore, Philippines, Thailand, Viet Nam
7	Sinopec Group	China	Chemicals, petroleum, rubber and plastic	21 670	316 548	Indonesia, Malaysia, Singapore, Thailand
8	Samsung Electronics	Korea, Republic of	Industrial, electric and electronic machinery	24 714	304 512	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Viet Nam
9	China State Construction Engineering	China	Construction	41 984	291 177	Indonesia, Malaysia, Singapore
10	China Merchants Group	China	Transport, freight and storage	28 293	277 071	Malaysia, Singapore
11	Evergrande Real Estate Group	China	Property services	25 483	266 410	Singapore
12	CHN Energy Investment Group	China	Business services	9 955	250 506	Indonesia, Singapore
13	Chinavanke	China	Property services	23 786	247 603	Singapore
14	China Communications Construction Group	China	Construction	28 557	231 346	Indonesia, Malaysia, Singapore, Thailand
15	Sony Group	Japan	Communications	30 912	211 953	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
16	Nippon Telegraph and Telephone	Japan	Communications	9 509	211 722	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
17	Honda Motor	Japan	Transport manufacturing	24 585	188 238	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
18	State Power Investment	China	Utilities	4 040	170 937	Viet Nam
19	Korea Electric Power	Korea, Republic of	Utilities	1 677	170 667	Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore
20	Hyundai Motor	Korea, Republic of	Transport manufacturing	15 576	168 002	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam

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Annex table 1.1. The 100 largest MNEs from non-ASEAN RCEP countries in ASEAN, by total assets, 2020 (Continued)

	MNE	Headquarters	Industry/activity	Cash and cash equivalent, 2020[a] ($ million)	Total assets, 2020* ($ million)	ASEAN countries with subsidiaries
21	Mitsubishi	Japan	Wholesale	12 169	166 050	Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
22	Greenland Holdings	China	Property services	12 724	163 977	Philippines, Singapore
23	Hanwha	Korea, Republic of	Chemicals, petroleum, rubber and plastic	3 084	157 442	Indonesia, Malaysia, Myanmar, Singapore, Thailand
24	Nissan Motor	Japan	Transport manufacturing	15 115	156 179	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
25	China Railway Construction	China	Construction	22 968	154 750	Malaysia, Singapore
26	China Railway Group	China	Construction	22 636	151 144	Malaysia, Singapore, Thailand
27	Poly Developments and Holdings Group	China	Property services	19 954	147 876	Singapore
28	China Minmetals	China	Wholesale	12 111	133 035	Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Viet Nam
29	Sunac Real Estate Group	China	Property services	17 012	131 287	Singapore
30	China Cosco Shipping	China	Transport, freight and storage	16 023	125 523	Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
31	Huawei Investment & Holding	China	Wholesale	24 429	122 894	Cambodia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
32	China Mobile Communications	China	Communications	9 243	122 808	Lao People's Democratic Republic, Singapore
33	Saic Motor	China	Transport manufacturing	23 271	121 559	Indonesia, Malaysia, Thailand
34	China National Chemical	China	Chemicals, petroleum, rubber and plastic	11 175	120 790	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
35	China National Nuclear	China	Utilities	9 537	119 037	Indonesia, Malaysia, Myanmar, Singapore, Thailand, Viet Nam
36	Takeda Pharmaceutical	Japan	Chemicals, petroleum, rubber and plastic	5 866	117 949	Indonesia, Malaysia, Philippines, Singapore, Thailand
37	China Huadian	China	Utilities	2 002	117 678	Indonesia, Singapore, Viet Nam
38	Power Construction Corporation of China	China	Construction	10 021	116 392	Singapore, Thailand
39	SK Holdings	Korea, Republic of	Business services	7 437	114 537	Indonesia, Malaysia, Myanmar, Singapore, Thailand, Viet Nam
40	Tokyo Electric Power Company Holdings	Japan	Utilities	7 482	110 008	Indonesia, Lao People's Democratic Republic, Philippines, Singapore, Thailand, Viet Nam
41	Mitsui	Japan	Wholesale	9 740	108 614	Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam

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Annex table 1.1. The 100 largest MNEs from non-ASEAN RCEP countries in ASEAN, by total assets, 2020 (Continued)

	MNE	Headquarters	Industry/activity	Cash and cash equivalent, 2020[a] ($ million)	Total assets, 2020[a] ($ million)	ASEAN countries with subsidiaries
42	China Datang	China	Utilities	1 779	108 564	Singapore, Viet Nam
43	China General Nuclear Power	China	Utilities	1 884	106 860	Singapore
44	Shandong Hi-Speed Group	China	Transport, freight and storage	7 415	103 299	Singapore
45	Aeon	Japan	Retail	15 394	101 121	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
46	BHP Group	Australia	Mining and extraction	15 613	100 861	Indonesia, Malaysia, Philippines, Singapore
47	China Telecom	China	Communications	3 495	100 634	Lao People's Democratic Republic, Malaysia, Singapore, Thailand, Viet Nam
48	Itochu	Japan	Wholesale	5 623	100 456	Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
49	Aluminum Corporation of China	China	Metals and metal products	7 412	93 661	Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand
50	Hitachi	Japan	Industrial, electric and electronic machinery	7 473	91 353	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
51	Legend Holdings	China	Business services	8 922	89 319	Indonesia, Malaysia, Philippines, Singapore, Thailand
52	Central Japan Railway	Japan	Transport, freight and storage	6 991	88 345	Indonesia
53	KDDI	Japan	Communications	3 449	88 134	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
54	COFCO	China	Wholesale	8 228	85 585	Indonesia, Malaysia, Singapore, Thailand, Viet Nam
55	China National Building Material Group	China	Chemicals, petroleum, rubber and plastic	6 599	85 329	Brunei Darussalam, Malaysia, Philippines, Singapore
56	Rakuten Group	Japan	Retail	18 681	83 996	Malaysia, Singapore, Thailand
57	Dalian Wanda Commercial Management Group	China	Property services	9 413	82 326	Singapore
58	China United Network Communications	China	Communications	5 563	80 754	Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
59	Overseas Chinese Town Holdings	China	Property services	8 357	79 082	Indonesia, Singapore
60	East Japan Railway	Japan	Transport, freight and storage	1 416	78 538	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
61	Sinochem Group	China	Business services	4 977	78 399	Indonesia, Malaysia, Singapore, Thailand

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Annex table 1.1. The 100 largest MNEs from non-ASEAN RCEP countries in ASEAN, by total assets, 2020 (Continued)

	MNE	Headquarters	Industry/activity	Cash and cash equivalent, 2020[a] ($ million)	Total assets, 2020[a] ($ million)	ASEAN countries with subsidiaries
62	China Shipbuilding Industry	China	Transport manufacturing	19 870	75 933	Singapore, Thailand
63	Sumitomo	Japan	Wholesale	6 554	74 780	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
64	Eneos Holdings	Japan	Chemicals, petroleum, rubber and plastic	3 667	73 701	Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
65	China Faw Group	China	Transport manufacturing	5 570	70 139	Indonesia
66	The Kansai Electric Power	Japan	Utilities	2 572	70 034	Indonesia, Philippines, Singapore, Thailand, Viet Nam
67	Nippon Steel	Japan	Metals and metal products	2 663	68 491	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
68	China Aerospace Science and Technology	China	Wholesale	10 333	68 346	Lao People's Democratic Republic
69	Posco	Korea, Republic of	Metals and metal products	3 332	68 284	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
70	HBIS Group	China	Metals and metal products	7 659	66 131	Singapore
71	Metallurgical Corporation of China	China	Construction	6 251	65 623	Singapore, Viet Nam
72	China Fortune Land Development	China	Industrial, electric and electronic machinery	6 149	65 523	Brunei Darussalam, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Viet Nam
73	China National Building Material	China	Leather, stone, clay and glass products	4 181	63 894	Brunei Darussalam, Malaysia
74	China North Industries Group	China	Industrial, electric and electronic machinery	13 639	61 314	Indonesia, Lao People's Democratic Republic, Myanmar, Singapore
75	Huaneng Power International	China	Utilities	1 904	61 292	Singapore, Thailand
76	Guangzhou R&F Properties	China	Property services	5 501	61 160	Cambodia, Malaysia, Singapore
77	Marubeni	Japan	Wholesale	4 808	58 142	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam.
78	China Electronics Technology Group	China	Industrial, electric and electronic machinery	11 816	57 688	Cambodia, Indonesia, Malaysia, Singapore, Thailand
79	Panasonic	Japan	Industrial, electric and electronic machinery	9 351	57 208	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
80	Zhejiang Geely Holding (Group)	China	Business services	11 984	56 632	Indonesia, Malaysia, Singapore, Thailand, Viet Nam
81	China National Machinery Industry	China	Industrial, electric and electronic machinery	11 532	54 904	Cambodia, Lao People's Democratic Republic, Malaysia, Myanmar, Singapore, Viet Nam
82	CRRC	China	Transport manufacturing	7 740	54 898	Singapore

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Annex table 1.1. The 100 largest MNEs from non-ASEAN RCEP countries in ASEAN, by total assets, 2020 (Concluded)

	MNE	Headquarters	Industry/activity	Cash and cash equivalent, 2020[a] ($ million)	Total assets, 2020[a] ($ million)	ASEAN countries with subsidiaries
83	Seven & I Holdings	Japan	Retail	12 411	54 816	Indonesia, Philippines
84	Denso	Japan	Transport manufacturing	5 500	51 994	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
85	Zhuhai Huafa Group	China	Property services	6 466	51 788	Singapore
86	Beijing Enterprises Group	China	Business services	5 782	51 614	Cambodia, Malaysia, Singapore, Thailand
87	Fujian Sunshine Group	China	Media and broadcasting	6 876	51 472	Singapore
88	Shandong Iron & Steel Group	China	Metals and metal products	4 991	51 109	Singapore
89	Japan Tobacco	Japan	Food and tobacco manufacturing	3 273	50 890	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
90	Chubu Electric Power	Japan	Utilities	1 372	50 784	Indonesia, Lao People's Democratic Republic, Philippines, Singapore, Thailand
91	China Aerospace Science and Industry	China	Transport manufacturing	13 311	49 913	Indonesia, Malaysia, Singapore, Thailand
92	China International Capital	China	Business services	10 365	49 373	Singapore
93	AVIC Capital	China	Transport, freight and storage	12 399	48 893	Malaysia, Singapore
94	BOE Technology Group	China	Industrial, electric and electronic machinery	8 154	48 721	Singapore
95	Baoshan Iron & Steel	China	Metals and metal products	1 923	48 609	Singapore, Thailand
96	China Tower	China	Communications	891	48 385	Lao People's Democratic Republic
97	Kia Motors	Korea, Republic of	Transport manufacturing	5 141	47 802	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
98	China Electronics	China	Media and broadcasting	8 242	46 875	Malaysia, Philippines, Singapore, Thailand
99	Beijing Urban Construction Group	China	Construction	5 416	46 728	Malaysia, Singapore
100	Shanghai Electric	China	Business services	4 068	45 807	Brunei Darussalam, Viet Nam
Total				**1 123 219**	**13 653 624**	

Source: *ASEAN Investment Report 2020–2021* research, based on Orbis.
Note: Ranked by total assets.
[a] Based on 2020 financial statement.

Annex 2.1. National investment laws and instruments (Selected cases)

Brunei Darussalam amended the Companies Act Order and Companies (Striking Off) Rules with effect from 13 September 2018. The amendment further strengthened the Companies Act (Chapter 39) and ensured a more effective enforcement system for striking off companies from the Register, respectively. It also introduced Insolvency Rules 2018, which took effect from 19 September 2018, to further strengthen its legal framework for insolvency.

The *Lao People's Democratic Republic* approved in December 2019 the amendment to Article 12 of the 2016 Law on Investment Promotion, No. 14/Na, to be consistent with the Law on Value-Added Tax and other relevant national regulations. In August 2020, it amended the Law on Land No. 70/Na, which permits foreign investors to own apartments and invest in condominium construction.

Myanmar enacted a Tourism Law on 17 September 2018 pertaining to license application for tourism services. It enacted the Insolvency Law (14 February 2020) and issued its Implementing Rules on 28 April 2020, followed by implementation of an online registry mechanism for insolvency proceedings. Four laws related to intellectual property rights were enacted in 2019 (i.e. the Trade Mark Law and Indus¬trial Design Law (passed on 30 January 2019), the Patent Law (11 March 2019), and the Copyright Law (24 May 2019)).

The *Philippines* amended the 38-year-old Corporation Code on 20 February 2019 and signed into law the Innovative Startup Act on 26 April 2019. The latter consists of programmes, benefits and incentives for start-ups and start-up enablers. It issued a circular on 30 October 2020 that allowed 100 per cent foreign ownership in large-scale geothermal exploration, development and utilization projects, subject to certain conditions (e.g. a minimum investment of $50 million).

Singapore amended its Companies Act, which entered into force on 31 August 2018 to ensure that Singapore remained business friendly and competitive.

Thailand passed three acts related to the Thailand 4.0 digital reform initiative, which covers the Electronic Transactions Act, published on 14 April 2019, and the Personal Data Protection Act and the Cyber Security Act, published on 27 May 2019.

Viet Nam amended its Law on Investment 2019 and Law on Enterprises 2019 on 17 June 2020; they came into force on 1 January 2021. These revised laws aim to create a more favourable, trans¬parent, fair, safe and friendly business and investment environment. The amended Law on Investment covers some important changes such as the definition of "foreign investor" as holding 50 per cent or more equity interest (instead of the current law's 51 per cent), as well as investment guarantees (e.g. property ownership, investment activities and the right to transfer assets abroad), additional investment incentives, the ability to take investment disputes between foreign investors and the State to international arbitration and the granting of national treatment for market access to foreign investors. Viet Nam also enacted a Law on PPP Investment on 18 June 2020, to create a more stable legal environment for PPP projects. In 2020, the Government introduced a negative list on market access, providing foreign investors with national treatment except in the sectors in the negative list.

Source: ASEAN Secretariat.

Annex 2.2. National investment facilitation and promotion measures in ASEAN, 2018–2020 (Selected cases)

Brunei Darussalam introduced a single-step process in simplifying procedures to start a business, amended its Stamp Act by removing the requirement for share certificates to be stamped upon incorporation and streamlined the approval process for getting electricity. The country's Ease of Doing Business Secretariat conducted workshops for the business community to further improve and streamline business-related processes and regulations. It established the businessBN website (www.business.gov.bn), which provides information on government processes for starting, running and growing business in the country.

Cambodia set out specific policies to improve the investment environment at the 18th Government–Private Sector Forum, held in May 2019. These policies included digitalization and simplification of business registration. It launched an online system for investment application on 15 June 2020, so as to approve applications within eight working days. Fees may be paid online through various e-payment channels. The Government strengthened the Council for the Development of Cambodia, to coordinate monitoring and evaluation of investment policies through a system of quarterly and annual reporting. At the forum, participants identified a number of policies that would help develop a favourable business and investment environment (e.g. trade restrictions, tax incentives for small and medium-sized enterprises (SMEs), reform of governmental institutions).

Indonesia adjusted its domestic regulations on incentives and its business license service standard following the launch of the President's Regulation to Accelerate Ease of Doing Business. On 9 July 2018, it launched an Online Single Submission system, a web-based business licensing system to reduce red tape. In late m2018, it published 16 economic policy packages based on sectoral and thematic issues (such as harmonization of regulations, simplification of bureaucratic processes and assurance of law enforceability). As of January 2019, under these packages, the Government had deregulated 222 out of 225 regulations. A new regulation (MOT Regulation No. 50 of 2020, on 19 May 2020) was issued to classify e-commerce actors and simplify requirements (e.g. business licensing and advertising) for foreign investment in the industry. On 2 November 2020 the Government enacted the Omnibus Law to improve the ease of doing business by, among other things, simplifying licensing processes, providing incentives, amending regulations of the Labour Law, relaxing immigration rules and harmonizing various sector-specific laws and regulations.

The *Lao People's Democratic Republic* in February 2018 implemented Prime Minister's Order No. 02/PM Improvement of Regulations and Coordination Mechanism of Doing Business, which included simplification of procedures for obtaining licenses and registered company seals. On 21 January 2020, under Prime Minister's Order No. 03/PM (21 January 2020), it implemented the One-Stop Service to improve the process of issuing investment and business licenses by providing investment information and au¬thorizing concessions. The Government announced issuing guidelines on fiscal incentive policy and leasing fees or concessions for loan for investment applications.

Myanmar implemented Myanmar Companies Online (MyCO), an electronic registry for companies, pursuant to the Myanmar Companies Law, which came into effect on 1 August 2018. It is also establishing an online investment application system, which is expected to come into effect in late 2020 or early 2021. A new Investment Promotion Committee was established, following the launch of the Myanmar Investment Promotion Plan on 18 October 2018. The plan aims to attract more than $200 billion in investment over the next 20 years. It outlines strategies to actively promote investment, including introducing new policies and regulations, and supporting institutional and infrastructure development. The Myanmar Investment Commission issued Notification No. 9/2020 pertain¬ing to the investor grievance mechanism on 7 April 2020. It involves administrative processes to address investors' grievances but does not provide avenues to resolve disputes between investors, investors and communities, or inves¬tors and the Government over a government contract apart from the right to use government land or buildings.

Myanmar also recently issued notifications governing investment applications and administra¬tive forms. Notification No. 37/2019 was issued on 18 July 2019 to reflect changes to the investment proposal form and endorsement application form to include additional information. The Directorate of Investment and Company Administration issued Notification No. 84/2019 on 20 September 2019, regarding the reduction of fees for incorporation of private companies and overseas corporations, as well as for lodgement of annual returns. The Myanmar Investment Commission issued an announcement on 26 Septem¬ber 2019 requiring companies operating businesses under its permits or endorse¬ments to obtain prior approval from the MIC for certain changes in their capital and their busi¬ness location. The President's Office issued Notification No. 104/2019 on 2 Octo¬ber 2019 requiring companies and State-owned enterprises in the extractive sectors to disclose information related to their beneficial owners.

The *Philippines*, on 28 May 2018, enacted Republic Act No. 11032, a law facilitating ease of doing business in transactions with the Government. The law streamlines government services, especially for business-related transactions. An Innovative Startup Act that facilitates movement of people was introduced. It includes the creation of "Start-up Visas" for foreign participants and the operationalization of the Asia-Pacific Economic Cooperation Business Travel Card. Administrative Order No. 23, signed on 21 February 2020, directs national government agencies to hasten reforms of their processes to eliminate overregulation and promote the efficiency of government processes. Executive Order No. 85, signed on 19 July 2019, allows duty-free importation of capital equipment, spare parts and accessories needed in the implementation of projects registered under the Board of Investment.

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Annex 2.2. National investment facilitation and promotion measures in ASEAN, 2018–2020 (Selected cases) (Concluded)

Singapore facilitated investment with a transparent and online licensing portal (i.e. LicenceOne) for the application of licenses and permits. The Singapore Land Authority enhanced its STARS eLodgment system in June 2018 to streamline the land administration process and improve the efficiency of law firms involved in conveyancing and real estate work. Singapore also simplified the process of filing annual returns for solvent, exempt private companies and private dormant relevant companies with pre-filled annual returns. These companies need only to verify that the information in the annual returns is correct before submission. The online annual return form came into effect on 27 December 2019 to reduce the administrative burden and improve the ease of doing business. On 4 May 2020, it launched a Patent Fast-Track Program to expedite the application-to-grant process of patents in all technology fields, cutting it from two years to six months.

In Thailand a "regulatory guillotine" initiative, currently being implemented through a Fast-Action Law Reform Committee under the Prime Minister's Office, aims to further streamline and simplify Thailand's law and regulations. The initiative involves reviewing any legal acts, licenses, procedures or regulations which are no longer neces¬sary, out-of-date and constraining doing businesses in the country. Thailand has also launched an online document submission service (e-submission) since 30 March 2020. This is in addition to existing e-services such as e-investment for applications and e-tax for authorization of corporate income tax exemption.

The Government launched the Thailand Investment Year 2019 initiative to stimulate investment and enhance the country's competitiveness. The initiative includes provision of investment incentives to promote large-scale investment in targeted technology-advanced industries. Promotion of investment opportunities in the Eastern Economic Corridor (EEC), which covers three provinces (i.e. Chachoengsao, Chonburi and Rayong) were conducted. The development of the EEC is connected to the country's drive towards an era of Thailand 4.0. The investment incentives package is extended and revised for projects in the EEC, and in knowledge-based, high-tech and high value added activities. Five more "Food Innopolis" sites have been approved as science and technology zones to help move the country towards be¬coming a global food innovation hub. Also announced in 2019 were smart city development activities, which are eligible for investment promotion, including rights and privileges over an extended period for tax exemption, import duty exemption and reduction of corporate income tax.

The Thai Board of Investment launched a SMART Visa online clinic in February 2018, which provides consultation service for foreign talent, investors, senior executives and start-ups. The clinic also provide information on SMART Visa benefits, criteria and conditions, application process and documentation require-ments. Initiatives to promote investment into prioritized sector, subregion, and human resources development were introduced. For instance, under a stimulus package called Thailand Plus (introduced on 6 September 2019) additional tax incentives are offered for (a) accelerating investment in large projects that focuses on high-technology industries, and (b) those developing human resources and highly skilled workforce.

Viet Nam issued "Resolution on continued improvement of business environment" number 02/NQ-CP on 1 January 2019, specifying measures to improve the business environment and enhance national competitiveness by 2021.

Source: ASEAN Secretariat.

Annex 2.3. National pandemic-related FDI measures (Selected cases)

Brunei Darussalam in March 2020, announced pandemic-response measures on tax, utility and social security deductions or deferments. A 50 per cent discount on corporate income tax and a 15 per cent discount on water and electricity bills were offered to the tourism, hospitality (including hotels and lodging houses), restaurant, and air and water transportation industries for six months from 1 April 2020. A 30 per cent discount on rental rates of government buildings was provided to micro, small and medium-sized enterprises (MSMEs) in these industries. The Government waived import duties and taxes on PPE and pandemic-related health care products.

Cambodia provided stimulus packages primarily targeting the apparel manufacturing and tourism industries. For instance, hotels in major tourist areas and garment factories were exempted from tax between March 2020 and March 2021. Tax holidays were granted to other factories affected by the pandemic. Further supporting the manufacturing industry, Cambodia facilitated the importation of raw materials and other parts used for manufacturing. In addition to employers' contributions of $30 a month to eligible apparel and footwear manufacturing workers whose employment had been suspended, the Government extended an additional $40 a month subsidy to these employees and certain segments of the tourism industry until the end of March 2021. Foreign-owned factories are major employers in Cambodia's garment industry.

Indonesia introduced fiscal stimulus packages that cover subsidies and assistance, and accelerated the launch of a pre-employment card. The packages include relaxation of various taxes. Income tax discounts to eligible businesses from August to December 2020 were announced through Income Tax Article 25 (PPh Pasal 25). The Government relaxed tax rules related to income tax exemption (PPh 21), exempting employers and employees of affected industries (such as hospitality, transportation, construction, mining, and wholesale trade) from monthly income tax payments. The Government also implemented exemptions for import income tax (PPh 22), a 30 per cent reduction of tax income instalments (PPh 25) and a value added tax incentive for affected business sectors.

The Government also facilitated greater use of online systems for processing business applications and licenses. Application for tax allowance investment incentives through an online single submission system became effective on 11 August 2020.[1] The country's investment agency (BKPM) and the Ministry of Cooperatives and SMEs collaborated in providing matchmaking activities to facilitate partnerships between foreign (and major domestic) investors and local MSMEs. The actions included dissemination of information through seminars, business forums, and missions or delegation visits of government agencies, foreign companies and MSMEs.

The Government assisted the pharmaceutical and medical devices industry through reduction of business licensing requirements, acceleration of licensing processes and provision of special assistance services. These measures aim to make investment and production in the industry easier. Export of medical supplies, especially PPE, was restricted and import restrictions were eased. BKPM offered specific initiatives to facilitate and accelerate medical-related FDI projects. These actions included a "3+1 strategy", which comprised (i) accelerated realization of existing investments; (ii) completion of stalled investments; (iii) conduct of investment promotions; and (iv) building of internal cooperation to prepare for post-pandemic conditions.[2]

BKPM also offered other services to facilitate investment during the pandemic. These services cover the following areas:

i. Accelerate the development and operation of business activities through the issuance of letters of support to companies while observing the COVID-19 protocol.
ii. Provide recommendations for top executives or investors to obtain an entry permit or visit visa for exploring investment opportunities or relocation to Indonesia.
iii. Provide recommendations for expert foreign workers to enter Indonesia in the framework of investment realization or implementation.
iv. Conduct visits to companies and follow up with existing investment to support and facilitate the potential for expansion.
v. Accelerate and facilitate the business licensing approval process. The average number of business licenses issued per day during the pandemic (both online and offline) was between 4,000 and 5,000.

The *Lao People's Democratic Republic* provided fiscal incentives including temporary exemption from income tax, exemption from duties for pandemic-related goods, postponement of tax for tourism businesses and reduction of various types of administrative fees. It also supported businesses with deferred payment of water and electricity charges.

Malaysia introduced a series of stimulus packages to ease the impact of the pandemic, announcing the first emergency stimulus package on 27 February 2020. It adopted a set of measures to help reduce business costs. For example, it offered discounts on water and electricity bills for certain industries, and it granted lease exemptions for six months for the tourism and manufacturing industries and tax deductions for PPE expenses incurred by businesses.

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Annex 2.3. National pandemic-related FDI measures (Selected cases) (Continued)

Myanmar, in its COVID-19 Economic Relief Plan, announced on 27 April 2020, introduced a range of specific fiscal measures and policy responses for investment. These measures included (i) fast-tracking large-scale private investment projects; (ii) reviewing the status and impact of approved or implemented projects; and (iii) prioritizing high-impact or near-completion projects in health care and key economic infrastructure.

Investment procedures to manufacture medical products related to COVID-19 were simplified, especially those that target using vacant State-owned factories. A 50 per cent reduction of investment application fees for both domestic and foreign investors took effect on 20 April 2020. Other business support measures included exemption of the 2 per cent advance income tax on exports until 30 September 2020, and deferral of corporate income tax and commercial tax payments to 30 September 2020. The Government also deferred land lease payments for six months for hotel businesses affected. It exempted hotel and tour businesses from paying license fees for a year and exempted manufacturing firms affected from lease fees for three to six months. It also extended deadlines for payment of corporate income tax and commercial tax, and waived withholding taxes on exports. In supporting the health care sector, Myanmar expedited import clearance and fast-track investment approval related to PPE, medical equipment and medicines. It waived taxes and duties on medical supplies related to the prevention, control and treatment of COVID-19. Many investment-related public services were kept open during the pandemic, by providing more facilities online such as for investment applications and business licenses. The Directorate of Investment and Company Administration facilitated digital applications for stay permits and visa extensions for employees of foreign companies.

The *Philippines* implemented stimulus packages for recovery and building a resilient economy. Import duties and fees were exempted until 23 May 2020. Republic Act 11469 or the Bayanihan to Heal as One Act was enacted on 24 March 2020 to support supply and production of medical supplies and services. The Act provided incentives for importers and manufacturers of medical and health care equipment that are critical to the COVID-19 response. Under the Bayanihan 2 Act, manufacturers can carry over any operating loss from financial year 2020/2021 as a tax deduction from gross income over the next five taxable years.[3] Qualified manufacturers are also exempted from business taxes, import duties and other fees on a range of products, including production of medical equipment, PPE and raw materials relevant to the manufacturing of these items.

The Philippine Board of Investment granted a three-year income tax holiday and duty-free importation of capital equipment for tourism and tourism-related businesses that renovate to enhance health and safety features and processes. In addition to investment incentives, the agency also extended other support to foreign companies. It endorsed executives of foreign companies wishing to travel to the Philippines on essential business (e.g. manufacturing or exporting activities or those involved in the trading and retail of essential goods) during the pandemic.

As part of a broader campaign to support businesses through the pandemic, the Philippines assists manufacturers in strengthening their capabilities through re-purposing existing product lines (e.g. alcoholic liquor used to create alcohol disinfectants, ready-to-wear garments transformed into protective uniforms or medical gloves fashioned from rubber destined for balloons). The Board of Investment helped manufacturers create linkages with raw materials suppliers and ensure a steady supply of medical products in the country. It provided assistance and expertise to help businesses strengthen their PPE-related capabilities.

The business application and approval process was expedited. Business permits, licenses, certificates and authorizations are to be considered and approved within seven working days. Deadlines for filling of tax returns and payment of taxes and fees were extended.

Singapore supported business by waiving the foreign worker levy and providing rebates of S$750 per month for two months for levies paid in 2020. Some businesses (e.g. construction, marine and offshore process) received waivers and rebates or up to four months. The Government extended an automatic wage subsidy to companies that retain local employees and a salary subsidy (10–50 per cent) for those that hired eligible skilled Singaporeans before 31 March 2021. Other fiscal incentives relevant to MNEs included corporate income tax rebates (25 per cent, with a cap of S$15,000 per company); three-month deferrals of payment of that tax; freezing of the goods and services tax rate increase for 2021 and all government fees and charges from 1 April 2020 to 31 March 2021.[4] The Government also provided wage support from September to December 2020, and a package of support measures for SMEs and start-ups.[5]

The country's mergers and acquisitions (M&A) scheme was extended to 31 December 2025 to encourage and help enterprises, especially SMEs, to transform and grow through strategic acquisitions. The scheme allows eligible companies to claim tax deductions and relief from stamp duty for qualifying acquisitions. These benefits were applicable to acquiring companies of an ultimate holding company incorporated in and a tax resident of Singapore. Foreign-owned companies enjoying certain tax incentive schemes could apply for a waiver of this condition for M&As made before 1 April 2020. The stamp duty relief is applicable to M&As made before 1 April 2020.

In supporting the continued internationalization of Singapore companies, the Government provided overseas business development consultancy and market readiness assistance grants.[6] The grant will be enhanced with (i) removal of the cap on two applications per company per year, (ii) an increase in the grant cap from S$20,000 per year to S$100,000 per new country over three years and (iii) extension of the 70 per cent support level by three years to 31 March 2023. The maximum support level was raised from 70 per cent to 80 per cent for the period from 1 November 2020 to 30 September 2021.

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Annex 2.3. National pandemic-related FDI measures (Selected cases) (Concluded)

Thailand launched stimulus packages in the first half of 2020 to provide assis¬tance, tax relief and soft loans to businesses, especially MSMEs. Pandemic-related FDI measures to support and facilitate investors were introduced. These measures included (i) extension of the deadline for filing corporate income tax returns for the 2019 accounting year (Por.Ngor.Dor.50) to 31 August 2020, (ii) extension of the deadline for the application of corporate income tax exemption privileges to 31 July 2020, (iii) introduction of e-submission and e-services to facilitate investment, (iv) temporary relaxation of investment conditions, (v) support and promotion of rapid investment in medical manufacturing and (vi) support for both R&D activities and development of "smart farming".

An online document submission service was introduced on 30 March 2020, adding to the existing e-service facilities (e.g. e-investment for applications, e-tax for authorization of corporate income tax exemption, e-land for land ownership approval and online smart visa applications). The Thailand Department of Intellectual Property promoted the use of e-certification and e-signature mechanisms.

Investment incentives were provided to promote smart farming and R&D in many industries. Qualified investments in the medical industry received a reduction of 50 per cent on corporate income tax for an additional three years. Investment conditions were relaxed on affected investment activities promoted by the Thai Board of Investment (BOI). Deadlines were extended for duty-free importation of machinery and full operation start-up were extended. The scope of activities eligible for duty-free importation of materials used in research and development (R&D) were broadened. Provision of investment incentives and simplification of investment conditions were introduced to promote smart farming.

The BOI announced relief measure No. Por. 4/2563 on 12 May 2020 to help qualifying companies in promoted industries to mitigate the impact of the pandemic. These measures cover time extensions and operating conditions for certain benefits. For instance,

i. BOI-promoted companies with operation commencement deadlines that fell between 1 March and 30 June 2020 were granted an automatic six-month extension from the due date. These companies were entitled to the rights and privileges granted under the BOI-promoted projects during the extended period.
ii. BOI-promoted companies that had deadlines for exemption of duty for import of machinery and that began operations between 1 January and 30 June 2020 were eligible for a six-month extension. BOI-promoted companies under the same scheme whose deadlines did not fall between these dates could also apply to extend their deadlines for importing machinery and commencing operations.
iii. BOI-promoted companies with deadlines for obtaining international standards compliance certifications (e.g. ISO 9002, CMMI or equivalent) between 1 March and 30 June 2020, were granted an automatic four-month extension from the due date.

Thailand also introduced specific measures to facilitate acceleration of investment in the medical sector:

i. A reduction of 50 per cent of corporate income tax for an additional three years to qualified investments in the medical sector, aside from the usual three- to eight-year tax holidays. This measure covers projects that apply for promotion between 1 January and 30 June 2020 and must start production and generate income by 31 December 2020.
ii. Exemption of import duties on machinery to support the adjustment of existing production lines to manufacture medical devices or parts. The equipment had to be imported within 2020 and the application for production line adjustment needed to be filed by September 2020.
iii. Adjustments to the benefits granted for the production of raw materials used in the manufacture of medical products. Pharmaceutical grade alcohol production can be eligible for an eight-year corporate income tax exemption. Additional benefits (e.g. extending corporate income tax exemption to five years, from three years) are granted for the production of non-woven fabric used as raw materials for the production of medical masks or medical devices.

Viet Nam introduced Decree No. 37/2020/ND-CP on 30 March 2020 to update and expand the list of businesses and industries with access to investment incentives under Decree 118/2015/ND-CP. The decree underscores the Government's efforts to support businesses, particularly SMEs affected by the pandemic. It issued Resolution No. 84/NQ-CP on 29 May 2020, which introduced economic relief measures such as reduction of certain fees and charges, providing soft loans to MSMEs; it also granted tax deductibility for COVID-19 measures and eased regulations on foreign employees, trade and construction activities. It offered a 10 per cent reduction of electricity bills for certain businesses, extended the deadline for land rental fees, and facilitated the importation of raw materials, accessories and parts used for manufacturing.

The Government extended payment deadlines for value added tax, corporate income tax and land-use fees for businesses by five months. To stimulate demand for specific products, the Government reduced a registration tax by half and extended a deadline for excise tax payments on domestically produced or assembled cars.[7] As part of the national pandemic-related measures, Viet Nam reduced corporate tax in June 2020, from 20 per cent to 14 per cent, to help businesses with annual revenues of less than $8.6 million and fewer than 200 employees.

Source: ASEAN Secretariat.

[1] By accepting applications through the online single submission system, the Government can accelerate the evaluation process and decisions on granting incentives.
[2] *BKPM Press release*, "Manufacturing, Downstream Industry, and Medical Devices Sectors become Current Priorities", 14 May 2020.
[3] Board of Investments, "Strong new package of tax breaks and incentives for Philippine manufacturers", (https://boi.gov.ph/strong-new-package-of-tax-breaks-and-incentives-for-philippine-manufacturers/)
[4] EDB Singapore, "Supporting you through COVID-19" (https://www.edb.gov.sg/en/how-we-help/supporting-you-through-covid-19.html).
[5] Enterprise Singapore, "What does Budget 2020 mean for your business?" (https://www.enterprisesg.gov.sg/supplementary-budget-2020).
[6] Enterprise Singapore, "Supplementary Budget 2020: Market Readiness Assistance Grant" (https://www.enterprisesg.gov.sg/supplementary-budget-2020).
[7] *Hanoi Times*, "Vietnam govt waives taxes to boost economic recovery, 30 May 2020.

Annex table 2.1. Summary of the RCEP Agreement

Chapter No.	Title of Chapter	Summary
Chapter 2	Trade in Goods	Relates to trade liberalization. Key elements include granting national treatment, reduction or elimination of customs duties; elimination of non-tariff measures, duty-free temporary admission of goods; and commitments to the WTO export competition, including elimination of scheduled export subsidy for agricultural goods.
Chapter 3	Rules of Origin	Determines which goods originate under the RCEP Agreement and therefore eligible for preferential tariff treatment. Covers issues on (i) Rules of Origin and (ii) Operational Certification Procedures. Has two annexes: (i) the Product-Specific Rules, which cover all tariff lines at the HS 6-digit level; and (ii) Minimum Information Requirements, listing the required information for a Certificate of Origin or a Declaration of Origin.
Chapter 4	Customs Procedures and Trade Facilitation	Provides predictability, consistency, and transparency in the application of customs laws and regulations, and promote efficient administration of customs procedures and expeditious clearance of goods. The chapter contains elements that go beyond the WTO Trade Facilitation Agreement. Key elements include simplification and harmonization of customs procedures, enhance trade facilitation and prompt customs clearance of goods.
Chapter 6	Standards, Technical Regulations, and Conformity Assessment Procedures (STRACAP)	Governs mutual recognition of standards, technical regulations, and conformity assessment procedures, and strengthen information exchange and cooperation in this field. The Dispute Settlement Chapter does not apply to STRACAP Chapter, although non-application of dispute settlement is subject to review two years after entry into force of the RCEP Agreement.
Chapter 7	Trade Remedies	Covers (i) RCEP safeguard measures; and (ii) Anti-dumping and countervailing duties. Safeguard measures provide a transitional mechanism to address serious injury or threat of serious injury to a party's domestic industry. It reaffirms the rights and obligations of Members under the WTO Agreement on Safeguards. Anti-dumping and countervailing duties relate to the rights and obligations provided under the relevant WTO Agreements
Chapter 8	Trade in Services	Aims to liberalize trade in services through substantially remove restrictive and discriminatory measures affecting trade in services. Aims to liberalize trade in services through substantially remove restrictive and discriminatory measures affecting trade in services. Key elements: rules on market access, national treatment, most-favoured-nation treatment, and local presence. Schedules of Specific Commitments or Schedules of Reservations and Non-Conforming Measures, as well as additional commitments is based on the negative-list approach. This Chapter also includes provisions on the reasonability, objectivity, and impartiality of domestic regulations affecting trade in services, which go beyond equivalent rules in the existing ASEAN-Plus-One FTAs. **Annex on Financial Services** Covers liberalization of financial services while providing a robust prudential safeguard, which allow financial regulators to apply measures to preserve the integrity and stability of the financial system. Key elements: Parties to (i) ensure transparency of financial regulations, (ii) permit supply of new financial services, and (iii) refrain from preventing transfers and processing of information necessary for the conduct of the ordinary business. **Annex on Telecommunications Services** Covers rules pertinent to trade in public telecommunications services. Goes beyong existing ASEAN Plus One FTAs by including additional obligations such as (i) approaches to regulation, (ii) international submarine cable systems, (iii) unbundling of network elements, (iv) access to poles, ducts and conduits, (v) international mobile roaming, and (vi) flexibility in the choice of technology. These additional obligations aim to encourage greater cooperation towards strengthening the backbone of ICT infrastructure and supports and facilitates trade in services in the region. **Annex on Professional Services** Aims to facilitate engagement on the supply of professional services in the region. It includes recognition of professional qualifications, and encouragement to relevant bodies to negotiate arrangements for mutual recognition of professional qualifications, licensing or registration in professional services sectors of mutual interest.

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Annex table 2.1. Summary of the RCEP Agreement (Concluded)

Chapter No.	Title of Chapter	Summary
Chapter 9	Temporary Movement of Natural Persons (MNP)	Sets out commitments that facilitate the temporary entry and temporary stay of natural persons engaged in trade in goods, supply of services or conduct of investment. **Key elements:** Commitments on business visitors, intra-corporate transferees and other categories as specified in the Schedule of Specific Commitments. Establishes rules to grant temporary entry and temporary stay, including expeditious processing of complete applications and ensuring that any fees imposed are reasonable on temporary movement of natural persons. Covers obligations to enhance transparency on all relevant immigration formalities; maintaining mechanisms to respond to enquiries regarding laws and regulations affecting the temporary entry and temporary stay of natural persons.
Chapter 10	Investment	Aims to create an enabling investment environment by providing investment protection, liberalization, promotion, and facilitation. These provisions upgrade and enhance the existing ASEAN Plus One FTAs. **Key elements:** Most-favoured-nation treatment clause, and commitments on the prohibition of performance requirements that go beyond the WTO TRIMS Agreement. Schedule of Reservations and Non-Conforming Measures using the negative-list approach with standstill and ratchet mechanism improved investment facilitation provisions, which also address investor aftercare, such as assistance in the resolution of complaints and grievances, and a built-in work programme on ISDS provisions.
Chapter 11	Intellectual Property	Provides a balanced and inclusive approach to the protection and enforcement of intellectual property rights. **Key elements:** provisions relating to harmonizing the protection of intellectual property rights and beyond those covered under the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights provisions relating to technological protection measures and enforcement in the digital environment criminal procedures and penalties against unauthorized copying of a cinematographic work on a commercial scale streamline and align procedures for the establishment of certain intellectual property rights (e.g. electronic filing of applications and making relevant information available online).
Chapter 12	Electronic Commerce	Promotes e-commerce and the wider use of e-commerce, including enhance cooperation among the Parties. It encourages improvement of trade administration and processes by using electronic means. **Key elements:** (i) adopt or maintain a legal framework to support e-commerce development, (ii) protect personal information of e-commerce users and consumers using electronic commerce, (iii) address some data-related issues such as location of computing facilities and cross-border transfer of information by electronic means, (iv) maintain the current practice of not imposing customs duties for electronic transmissions. This Chapter is not subject to Dispute Settlement, but the general review of the RCEP Agreement will review the application of Dispute Settlement to this Chapter.
Chapter 14	Small and Medium Enterprises (SMEs)	Supports the development of SMEs, including micro enterprises. Key elements: (i) sharing of RCEP-related information relevant to SMEs. Information include the full text of the RCEP Agreement, trade and investment-related laws and regulations pertinent to SMEs, and other business-related information useful for SMEs to benefit from the RCEP Agreement. (ii) strengthen cooperation such as in e-commerce, intellectual property rights, access to markets, and innovation.

Source: ASEAN Secretariat.

Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Siemens (Industrial Automation)	Germany	Industrial automation (under the Digital Enterprise portfolio of the company)	13 625	Cambodia (representative office) Indonesia (5 offices, 1 manufacturing facility for smart infrastructure and distribution systems) Malaysia (1 country office, 2 manufacturing facilities for semiconductors, 1 South East Asian Technical Competency Hub) Myanmar (1 office, 1 training centre) Philippines (1 country office, 3 offices) Singapore (1 country office, 1 manufacturing facility, 1 consultancy office for digital factory manufacturing design, 1 digitalization hub, 1 advance manufacturing transformation centre) Thailand (1 country office which also oversees business development in Cambodia and Myanmar, 1 service centre) Viet Nam (3 offices, 1 factory for automation products, 1 digital industry academy)
Emerson Electric Corporation	United States	Automation solutions	12 255	Indonesia, Malaysia, Thailand, Viet Nam (1 office each) Philippines (1 regional headquarters) Singapore (1 automation solutions centre, 1 pervasive sensing centre of excellence, 1 analytical manufacturing and integration centre, 1 global additive manufacturing centre, 1 manufacturing facility)
ABB	Switzerland	Industrial automation, robotics and discrete automation	11 222	Brunei Darussalam (1 office) Cambodia (1 office) Indonesia (11 sales offices, 5 service centres/workshops, 4 manufacturing facilities on different types of switchgears, 1 R&D centre) Malaysia (2 offices, 1 manufacturing facility, and 1 robotics digital operation centre) Myanmar (office) Philippines (1 office and 4 service points/centres) Singapore (1 regional headquarters, 1 regional distribution hub, 1 customer innovation centre, 1 robotics digital operation/application centre, 1 regional robotics packaging application hub) Thailand (1 office, 1 manufacturing facility for switchgears, 1 business centre (sales), 4 service centres, 1 robotic application centre) Viet Nam (1 head office, 1 robotics and automation solution centre, 1 representative office, 1 electrification distribution solution factory, 1 robotics technical and service centre)
Schneider Electric	France	Energy and automation digital solutions	7 052	Brunei Darussalam (1 office) Indonesia (1 office, 2 smart factories (Cikarang "Engineer to Order" factory and Batam for controllers, drives, relays, sensors and contactors), 1 solution hub, 1 centre for excellence) Malaysia (1 office, 1 manufacturing facility) Myanmar (office) Philippines (1 office, 1 smart factory for electrical components including switchgears and protection relays) Singapore (1 East Asia and Japan Headquarters, 1 innovation hub) Thailand (1 office, 1 manufacturing facility for automation hardware) Viet Nam (1 office and 1 manufacturing for wiring products and electronic components for smart homes)
Rockwell Automation	United States	Industrial automation and information technology	6 737	Indonesia, Malaysia, Philippines, Thailand, Viet Nam (1 office respectively for sales, distribution and training functions) Singapore (1 regional hub, 1 manufacturing, 1 office for sales, distribution and training functions) Myanmar (appointed a local distributor/system integrator)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Continued)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Fortive	United States	Industrial technology solutions (hardware and software) including sensing technologies and field solutions	4 428	Singapore (2 subsidiaries, which also cover sales in Indonesia, Philippines, Thailand, Viet Nam; distributors) Malaysia (1 office)
Mitsubishi Electric	Japan	e-factory solutions and industrial automation	3 979	Malaysia and Thailand (1 office and 1 manufacturing facility each) Indonesia (1 office) Philippines (1 product service centre)
Honeywell International	United States	Building technologies, performance technologies, and safety and productivity solutions Performance technologies, process technologies and automation solutions, including connected solutions	3 756	Malaysia (1 regional headquarters, 1 automation college, 2 factories for membranes and electrical products, 1 APAC regional distribution centre) Indonesia (1 office) Philippines (1 office) Singapore (1 office, 1 automation solution centre, 1 automation college, 1 cyber security innovation centre) Thailand (1 office, 1 manufacturing facility for electronic materials) Viet Nam (1 office, 1 process solutions training centre)
Mitsubishi Electric	Japan	e-factory solutions and industrial automation	3 979	Malaysia and Thailand (1 office and 1 manufacturing facility each) Indonesia (1 office) Philippines (1 product service centre)
Yokogawa Electric	Japan	Industrial automation, test and measurement solutions	3 427	Indonesia (2 offices for sales, engineering and services) Malaysia (1 office for sales and services) Philippines (1 joint venture subsidiary for sales, distribution, customer support and training) Singapore (3 subsidiaries for manufacturing, sales, engineering and service functions; 1 regional headquarters) Thailand (1 joint venture subsidiary for sales, service, engineering, training functions, 1 joint venture company for services and installations) Viet Nam (2 offices for sales, engineering to after-sales services)
Ametek EIG	United States	Manufacture electronic instruments and electromechanical devices (including industrial automation hardware)	3 323	Indonesia (distributors) Malaysia (1 manufacturing facility for electronic components and packaging, distributors) Philippines (distributors) Singapore (1 regional centre for Asia, distributors) Thailand (1 office, distributors) Viet Nam (distributors)
Omron	Japan	IoT solutions and manufacture automation hardware, sensors	3 236	Indonesia (1 automation centre, 1 manufacturing facility for relays, switches, sockets and sensors) Malaysia (1 manufacturing facility for relays and parts, dies) Singapore (1 regional Asia Pacific hub, 1 automation centre) Thailand (1 automation centre)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Continued)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Endress + Hauser	Switzerland	Measurement instrumentation, services and solutions for industrial process engineering	3 113	Brunei Darussalam (distributors) Cambodia (distributors) Indonesia (1 office, 1 service centre) Malaysia (3 offices) Philippines (1 office) Singapore (1 regional headquarters, 1 office) Thailand (1 office) Viet Nam (1 office, distributors, 1 partnership with a local manufacturer)
Phoenix Contact	Germany	Manufacture industrial automation, interconnection, and interface solutions	2 912	Indonesia (1 sales subsidiary, distributors) Malaysia (1 sales subsidiary, distributors) Myanmar (1 sales subsidiary, distributors) Philippines (1 sales subsidiary, distriutors) Singapore (1 regional headquarters, 1 sales subsidiary, distributors) Thailand (1 sales subsidiary, distributor) Viet Nam (1 sales subsidiary, distributors)
Spectris	United Kingdom	Precision instrumentation and controls	2 085	Singapore (1 subsidiary for automation solutions, 1 office to coordinate businesses in ASEAN)
Sick AG	Germany	Manufacture sensors, industrial sensor solutions (factory automation, logistics automation and process automation)	2 013	Indonesia (1 representative office) Malaysia (1 office for sales and service) Philippines (1 distributor) Singapore (1 regional sales office and service centre, 1 regional competence centre) Thailand (1 office for sales and service) Viet Nam (1 representative office)
IMI Precision Engineering	United Kingdom	Precision engineering and industrial technology solutions	1 991	Malaysia (1 office) Singapore (1 office) Thailand (1 office)
MKS Instruments	United States	Industrial instruments, systems, and process control solutions	1 900	Singapore (1 sales and service office covering also Indonesia, Malaysia, Philippines, Thailand and Viet Nam); 1 manufacturing facility for laser-based micro manufacturing systems and component test systems
Festo	Germany	Industrial automation, industrial training and education	1 821	Malaysia (1 office) Philippines (1 office) Singapore (1 regional hub, 1 office) Thailand (1 office)
Advantech	Taiwan Province of China	IoT intelligent systems, Industry 4.0, machine automation, embedding computing, embedded systems	1 765	Indonesia (1 representative office) Malaysia (1 representative office) Singapore (1 representative office, 1 regional hub) Thailand (representative office) Viet Nam (1 representative office, 1 manufacturing subsidiary)
TechnipFMC	United Kingdom	Technology solutions and digital services for the energy industry	1 634	Indonesia (1 office for sales and service) Malaysia (1 office for sales and service) Singapore (1 regional headquarters, 1 R&D facility, 1 engineering and manufacturing hub) Thailand (1 office for sales and service) Viet Nam (1 office for sales and service)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Continued)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Fanuc	Japan	Industrial robots and automation	1 561	Indonesia (1 service centre for sales, distribution, after-sales services, training) Malaysia (1 service centre for sales, distribution, after-sales services, training) Philippines (1 service centre for sales, distribution, after-sales services, training) Singapore (1 service centre for sales, distribution, after-sales services, training) Thailand (1 service centre for sales, distribution, after-sales services, training) Viet Nam (1 service centre for sales, distribution, after-sales services, training)
GE	United States	Industrial automation solutions (hardware and software), IIoT, connecting machines, data analytics for power, health care, aviation, Ttansportation)	1 550	Cambodia (1 office) Indonesia (1 country office, 1 manufacturing facility for switchgears) Malaysia (1 regional headquarters, 1 country office, 1 tooling plant) Myanmar (1 office) Philippines (1 country office) Singapore (1 complex manufacturing facility, 1 engineering services, 1 research and customer applications development, 1 regional commercial operations, 1 Asia digital operations centre) Thailand (1 country office) Viet Nam (2 representative offices, 1 subsidiary, 1 manufacturing facility in Hai Phong)
Roper Technologies	United States	Diversified industrial company, manufacture engineering products and solutions	1 451	Malaysia (1 subsidiary) Singapore (1 subsidiary) Thailand (1 subsidiary) Viet Nam (1 subsidiary)
Baker Hughes	United States	Energy technology company	1 447	Malaysia (1 subsidiary) Singapore (1 regional headquarters, 4 subsidiaries, 1 manufacturing facility)
Aveva	United Kingdom	Information technology (industrial software solutions)	1 395	Malaysia (1 office for sales and training) Singapore (1 office for sales and training)
National Instruments	United States	Automated test equipment, automated measurement systems and virtual instrumentation software	1 353	Indonesia (1 office) Malaysia (1 office, 1 manufacturing facility, 1 R&D centre) Singapore (1 office) Viet Nam (1 office)
Flowserve	United States	Manufacture industrial and environmental machinery (e.g. valves, automation) and related services to energy and chemical industries	1 244	Brunei Darussalam (1 office, 1 quick response centre) Indonesia (1 office, 1 quick response centre, 1 manufacturing facility) Malaysia (1 office, 1 quick response centre, 1 manufacturing facility) Philippines (1 office, 1 quick response centre, 1 manufacturing facility) Singapore (1 regional office, 1 office, 1 quick response centre) Thailand (1 office, 1 quick response centre, 1 manufacturing facility) Viet Nam (1 office, 1 quick response centre)
Mettler-Toledo	United States	Manufacturer precision instruments and provide services for use in laboratories and manufacturing industries	1 234	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 office) Thailand (1 office) Viet Nam (1 office)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Continued)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
IFM	Germany	Innovative sensors, systems and solutions for modern automation	1 174	Indonesia (distributors) Malaysia (1 subsidiary) Philippines (distributors) Singapore (1 subsidiary) Thailand (distributors) Viet Nam (subsidiary)
Wika	Germany	Industrial measurement technology	1 170	Singapore (1 office) Thailand (1 office)
Wago	Germany	Smart automation solutions for automotive, manufacturing, power engineering, marine and offshore, other industries	1 120	Singapore (1 office)
Teledyne Instruments	United States	Manufacture gas and liquid analyzers, sensors and custom integrated analysis solutions	1 105	Indonesia (distributors) Malaysia (1 regional headquarters, distributors) Philippines (distributors) Singapore (distributors) Thailand (distributors) Viet Nam (distributors)
Yaskawa	Japan	Manufacture robots, cobots, AC servo drives and controller and other industrial automation hardware	1 100	Indonesia (1 robotic and technical centre, 1 office, distributors) Malaysia (1 office, distributors) Singapore (1 regional headquarters, 1 office, distributors) Thailand (1 robot centre, 1 office, distributors) Viet Nam (1 office, distributors)
Beckhoff	Germany	Automation systems (hardware/sofware) using PC-based control technology	1 060	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 office) Thailand (1 office) Viet Nam (1 office)
Weidmuller	Germany	Industrial connectivity products, solutions and services provider	927	Indonesia (representative office, distributors) Malaysia (representative office, distributors) Philippines (distributors) Singapore (sales office,distributors) Thailand (representative office, distributors) Viet Nam (representative office, distributors)
Harting	Germany	Industrial connectivity solutions for data, signals and power	881	Indonesia (1 office) Malaysia (1 office) Singapore (1 subsidiary)
Lenze	Germany	Industrial automation and digitization hardware and software solutions	880	Philippines (1 office) Singapore (1 office)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Continued)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Azbil Group (Yamatake)	Japan	Industrial technology solutions (hardware and software)	863	Indonesia (1 subsidiary) Malaysia (2 subsidiaries) Philippines (1 subsidiary) Singapore (1 regional headquarters, 1 subsidiary, 1 technical service centre) Thailand(1 subsidiary, 1 manufacturing subsidiary) Viet Nam (1 subsidiary)
Pepperl+Fuchs	Germany	Manufacture industrial products (e.g. sensors) for fabrication and process automation	839	Brunei Darussalam (1 subsidiary) Indonesia (1 manufacturing subsidiary, distributors) Malaysia (1 office, distributors) Philippines (distributor) Singapore (1 manufacturing subsidiary, 1 global distribution centre, distributors) Thailand (distributors) Viet Nam (1 manufacturing subsidiary, distributors)
Hitachi Industry Solutions	Japan	Use digital technologies, industrial and IT automation solutions to connect entire manufacturing businesses, smart manufacturing solutions	815	Indonesia (2 subsidiaries) Malaysia (2 offices, 1 manufacturing subsidiary) Myanmar (1 office) Philippines (2 offices) Singapore (2 offices, 1 manufacturing subsidiary, 1 regional headquarter) Thailand (1 office; 1 regional office overseeing Thailand, Cambodia and Lao People's Democratic Republic sales and after-sales activities; 1 regional smart factory hub, 1 manufacturing facility) Viet Nam (2 representative offices; 1 manufacturing facility)
Eaton Corporation	Ireland	Electrical and industrial/power management solutions	806	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 regional office, 1 customer service centre) Thailand (1 office) Viet Nam (1 office)
Thermo Fisher Scientific	United States	Industrial technology solutions, scientific instrumentation, and software and services to health care, life science, and other laboratories	798	Cambodia (distributor) Indonesia (distributors) Malaysia (1 office, 1 regional headquarters) Myanmar (distributor) Philippines (1 office) Singapore (1 office, 1 manufacturing facility) Thailand (1 office, distributors) Viet Nam (distributors)
Fuji Electric	Japan	Manufacture industrial technology hardware (e.g. inverters, semiconductors, data centre, sensors and measurements)	782	Cambodia (1 representative office) Indonesia (1 office, 1 manufacturing facility) Malaysia (2 offices, 1 manufacturing facility) Myanmar (1 branch office) Philippines (1 office, 1 manufacturing facility) Singapore (1 office, 1 manufacturing facility) Thailand (1 office, 2 manufacturing facilities) Viet Nam (3 offices)

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Annex table 3.1. Top 50 global industrial automation MNEs in ASEAN, 2020 (Millions of dollars) (Concluded)

Company	Headquarters	Activity	2019 global revenue	Presence in ASEAN (Selected cases)
Samson	Germany	Industrial automation hardware	777	Malaysia (1 office) Singapore (1 office) Thailand (1 office) Viet Nam (1 office)
Metso	Finland	Technology and end-to-end solutions and services for minerals processing, and metals refining industries	775	Indonesia (distributors) Malaysia (1 office, distributors) Myanmar (1 distributor) Philippines (1 distributor) Singapore (1 regional office, 1distributor) Thailand (1 office, distributors)
Bosch Rexroth	Germany	Industrial solutions for Industry 4.0 transformation (software solutions, service consulting, logistics and manufacturing (connected manufacturing)	775	Cambodia (office) Indonesia (1 office, distributors) Malaysia (3 manufacturing facilities and 3 offices, distributors) Myanmar (1 office) Philippines (1 representative office, distributors) Singapore (4 subsidiaries, 1 regional headquarters, 1 corporate information centre, 1 research and technology centre, distributors) Thailand (1 subsidiary, 1 office, 1 manufacturing facility at Hemaraj, 1 R&D centre, distributors) Viet Nam (1 subsidiary, 2 representative offices, 1 software and engineering centre, 1 training centre, distributors)
Turck	Germany	Industrial automation technology provider (such as sensor, interface and connection)	751	Indonesia (distributors) Malaysia (1 subsidiary) Myanmar (1 distributor) Philippines (1 distributor) Singapore (1 subsidiary, which also oversee sales in Indonesia, Myanmar, Philippines, Viet Nam) Thailand (Sales subsidiary, 1 distributor) Viet Nam (1 distributor)
Krohne	United Kingdom	Manufacture industrial process instrumentation and automation solutions	699	Indonesia (1 subsidiary) Malaysia (1 subsidiary) Philippines (authorized distributors) Singapore (1 subsidiary) Thailand (1 subsidiary) Viet Nam (1 subsidiary)
Horiba	Japan	Manufacture precision instruments for measurement and analysis	685	Indonesia (1 subsidiary) Philippines (1 office) Singapore (1 regional office, 1 sales and services office) Thailand (1 subsidiary) Viet Nam (1 subsidiary)

Source: *ASEAN Investment Report 2020–2021* research, based on Control Global, "Top 50 Automation Companies of 2019: Under Siege" (https://www.controlglobal.com/articles/2020/top-50-automation-companies-of-2019-under-siege/) and company websites.

Notes: (1) Some large dedicated hardware and software robotic companies may be excluded in the top 50 list.
(2) Baker Hughes merged with GE Oil and Gas.
(3) Emerson acquired GE Automation's Intelligent Platforms in 2019.

Annex table 3.2. Major additive manufacturing MNEs in ASEAN (Selected cases)

Company	Headquarters	Main activities	Presence in ASEAN
Autodesk	United States	Production of machines including AM machines, 3D design, engineering and software solutions	Indonesia (branch of Singapore subsidiary) Malaysia (branch of Singapore subsidiary) Philippines (branch of Singapore subsidiary) Singapore (Asia Pacific headquarters, sales office) Thailand (branch of Singapore subsidiary) Viet Nam (representative office)
BeAM (now part of AddUp)	France	Production and design of industrial metal AM machines	Singapore (Asia Pacific Solutions Centre)
3D Metalforge	United States	End-to-end AM services	Singapore (3D Metal Additive Manufacturing Centre) Singapore (regional headquarters)
CADFEM	Germany	3D printing solutions	Singapore (regional headquarters) Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand and Viet Nam (through partnership with Ansys (United States)
Creaform[a]	Canada	3D printers, automated measurement technologies and 3D printing solutions	Singapore (Asia-Pacific hub for Ametek (United States)
DMG Mori (Japanese-owned)	Germany	Production of industrial machines including additive machines, automation machines and manufacturing digitalization solutions	Indonesia (sales and service, showroom) Malaysia (sales and service, showroom) Singapore (sales and service, showroom, academy) Thailand (sales and service, showroom)
EOS	Germany	Production of AM machines (plastics and metals)	Singapore (Asia-Pacific regional office, warehouse and distribution hub)
Evonik Industries	Germany	Production of specialty chemicals and AM materials	Singapore (AM R&D)
Formlabs	United States	Production of 3D printers and solutions	Singapore (Asia-Pacific headquarters, sales office)
GE Additive	United States	Production of AM machines and metal additive manufacturing solutions	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam (sales offices) Singapore (regional hub for commercial activities, and R&D)
HP	United States	Production of 3D printing machines and solutions	Singapore (Asia Pacific headquarters and R&D facility) Sales offices (Malaysia, Philippines, Thailand, Viet Nam) Malaysia (Asia-Pacific hub for R&D, sales and services)
Materialise	Belgium	Development of 3d printing software solutions and services	Sales offices (Indonesia, Malaysia, Singapore, Thailand, Viet Nam)
Matsuura	Japan	Production of machine tools systems and AM systems/machine	Indonesia (office)
Mitsubishi Electric	Japan	Production of industrial automation machines, AM machines/systems and e-factory solutions	Malaysia (office) Philippines (product service centre) Thailand (office, manufacturing facilities for 3D printers, sales and marketing office and Industry 4.0 services)
New Kinpo Group	Taiwan Province of China	Production of industrial machineries including 3D printing machines	Other manufacturing facilities for precision production, automation (Malaysia, Philippines and Singapore) Singapore (Asia Pacific headquarters, 3D application centre)
Optomec	United States	Manufacturer of AM systems and solutions, including materials	Singapore (regional sales and services centre)
Renishaw	United Kingdom	Production of metal AM machines and development of AM solutions	Representative offices (Indonesia, Malaysia, Philippines, Thailand, Viet Nam) Singapore (regional headquarters)
Shonan Design	Japan	3D printing solutions	Cambodia (representative office)

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Annex table 3.2. Major additive manufacturing MNEs in ASEAN (Selected cases) (Concluded)

Company	Headquarters	Main activities	Presence in ASEAN
Siemens Digital Industries ASEAN	Germany	Software solutions for automation and AM	Indonesia (five offices) Malaysia (country office) Myanmar (office) Philippines (country office, three offices) Singapore (country office, Advance Manufacturing Transformation Centre, one consultancy entity for digital factory manufacturing design, one digitalization hub) Thailand (country office which also oversees business development in Cambodia and Myanmar) Viet Nam (office) Singapore (Asia-Pacific headquarters, R&D functions)
SLM Solutions Group	Germany	Manufacturer of AM machines and end-to-end integrated AM solutions provider	Singapore (technology centre and sales/services)
Sodick	Japan	Production of metal 3D printing machines and other technologies	Thailand (production facility, sales and services) Sales and services (Indonesia, Malaysia, Philippines Viet Nam) Singapore (regional headquarters for Southern Asia and Pacific, and sales)
Stratasys	United States–Israel	Production of AM machines and applied additive technology solutions services for industries	Indonesia (sales office)
Trumpf	Germany	Production of industrial machines including AM systems/machines and industrial solutions	Brunei Darussalam (office) Malaysia (sales office) Philippines (sales office) Singapore (sales office) Thailand (sales office) Viet Nam (sales office)
Thyssenkrupp	Germany	Industrial solutions including AM solutions (i.e. designing, creating and printing for clients)	Indonesia (sales office) Malaysia (sales office) Philippines (sales office) Singapore (sales office, one AM TechCenter Hub) Thailand (sales office) Viet Nam (sales office) Singapore (Asia headquarters, cleaning and coating operations) Singapore (Asia Pacific headquarters) and commercial presence (through resellers)
Ultra Clean Holdings	United States	End-to-end 3D printing services	Singapore (Voestalpine Additive Manufacturing Centre, R&D and manufacturing for metal AM)
Ultimaker	Netherlands	Production of 3D printers and 3D printing solution software	Singapore (regional headquarters, R&D and smart factory)
Voestlapine	Austria	Steel and technology group including production of AM machine	Indonesia, Malaysia, Viet Nam (technical centres)
Yamazaki Mazak	Japan	Production of AM machines and other advanced technology solutions	Thailand (technology centre)

Source: *ASEAN Investment Report 2020–2021* research, based on industry reports, company websites and annual reports, and media.
Note: Compiled from the following lists of top AM companies in Europe, Japan and the United States:
(i) Top 10 global additive manufacturing service suppliers (https://www.thomasnet.com/articles/top-suppliers/top-suppliers-of-additive-manufacturing-consulting-services)
(ii) Top 10 additive manufacturing and 3D printing companies in Europe
(iii) Major AM service suppliers in the United State (https://www.thomasnet.com/articles/top-suppliers/top-suppliers-of-additive-manufacturing-consulting-services)
(iv) Major AM players in Japan (https://www.metal-am.com/articles/the-current-status-and-outlook-for-metal-additive-manufacturing-in-japan)
Office presence is not specific to AM-related operations. Offices could also offer a company's entire range of products and services relating to AM and automation. Presence covers both physical presence and "significant partnerships on innovation and/or training" established by the companies.
[a] A subsidiary of Ametek (United States).

Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020

Company	Headquarters	IIoT Solutions	Presence in ASEAN
Siemens	Germany	IoT hardware and software solutions	Cambodia (representative office) Indonesia (5 offices, 1 manufacturing facility for smart infrastructure and distribution systems) Malaysia (1 office, 2 manufacturing facilities for semiconductors, 1 Southeast Asia Technical Competency Hub) Myanmar (1 office, 1 training centre) Philippines (1 country office, 3 offices) Singapore (Singapore (1 country office, 1 manufacturing facility, 1 consultancy entity for digital factory manufacturing design, 1 digitalization hub, 1 advance manufacturing transformation centre) Thailand (1 office which also oversees business development in Cambodia and Myanmar, 1 service centre) Viet Nam (3 offices, 1 factory for automation products, 1 digital industry academy)
PTC	United States	IoT software solutions	Malaysia (1 office) Singapore (1 office) Thailand (1 office) Viet Nam (1 office)
ABB	Switzerland	IoT hardware (e.g. sensors, processors) and software solutions	Brunei Darussalam (1 office) Cambodia (1 office) Indonesia (11 sales offices, 5 service centres/workshops, 4 manufacturing facilities on different types of switchgears, 1 R&D centre) Malaysia (2 offices, 1 manufacturing facility, and 1 robotics digital operation centre) Myanmar (office) Philippines (1 office and 4 service points/centres) Singapore (1 regional headquarters, 1 regional distribution hub, 1 customer innovation centre, 1 robotics digital operation/application centre, 1 regional robotics packaging application hub) Thailand (1 office, 1 manufacturing facility for switchgears, 1 business centre (sales), 4 service centres, 1 robotic application centre) Viet Nam (1 head office, 1 robotics and automation solution centre, 1 representative office, 1 electrification distribution solution factory, 1 robotics technical and service centre)
Intel	United States	IoT hardware (e.g. sensors, drones, processors) and software solutions (including cloud computing)	Indonesia (office) Malaysia (2 offices; 2 manufacturing facilities) Singapore (1 regional headquarters; 1 office) Viet Nam (1 office; 1 manufacturing facility)
Schneider Electric	France	IoT hardware (e.g. senosrs, drives, controls, switchgears) and software solutions (including cloud services, remote monitoring, predictive analytics, cloud analytics)	Brunei Darussalam (1 office) Indonesia (1 office, 2 smart factories (Cikarang "Engineer to Order' factory and Batam for controllers, drives, relays, sensors and contactors), 1 solution hub, 1 centre for excellence) Malaysia (1 office, 1 manufacturing facility) Myanmar (office) Philippines (1 office, 1 smart factory for electrical components including switchgears and protection relays) Singapore (1 East Asia and Japan headquarters, 1 innovation hub) Thailand (1 office, 1 manufacturing facility for automation hardware) Viet Nam (1 office and 1 manufacturing for wiring products and electronic components for smart homes)
Honeywell International	United States	IoT hardware (e.g. sensors, automation and control, actuators) and software solutions (including analytics and modeling).	Indonesia (1 office) Malaysia (1 regional headquarters, 1 automation college, 2 factories for membranes and electrical products), 1 distribution centre for Asia-Pacific) Philippines (1 office) Singapore (1 office, 1 automation solution centre, 1 automation college, 1 cyber security innovation centre) Thailand (1 office, 1 manufacturing facility for electronic materials) Viet Nam (1 office, 1 process solutions training centre)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Continued)

Company	Headquarters	Main activities	Presence in ASEAN
Huawei	China	IoT hardware (e.g. processors) and software solutions (including networks, connectivity, edge intelligence, analytics).	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (regional headquarters) Thailand (1 office)
SAP	Germany	IoT software solutions (e.g. analytics and modeling)	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 regional headquarters) Thailand (1 office) Viet Nam (2 representative offices)
Advantech	Taiwan Province of China	IoT hardware e.g. processors, automation and control technologies) and software solutions (including embedded automation solution platforms, edge intelligence)	Indonesia (1 representative office) Malaysia (1 representative office) Singapore (1 representative office, 1 regional hub) Thailand (representative office) Viet Nam (1 representative office, 1 manufacturing subsidiary)
Bosch	Germany	IoT hardware (e.g. sensors, automation and control, and robots technologies) and software solutions (including analytics and modeling, connectivity)	Cambodia (office) Indonesia (1 office and authorized distributors) Malaysia (3 manufacturing facilities and 3 offices, authorized distributors) Myanmar (1 office) Philippines (1 representative office, authorized distributors) Singapore (4 subsidiaries, 1 regional headquarters, 1 corporate information centre; 1 research and technology Centre for Asia Pacific, authorized distributors) Thailand (1 office, 1 manufacturing facility at Hemaraj, 1 R&D centre at Hemaraj, authorized distributors) Viet Nam (1 subsidiary, 2 representative offices, 1 software and engineering centre, 1 training centre, authorized distributors)
Cisco Systems	United States	IoT hardware (i.e. network and connectivity technologies) and software solutions	Indonesia (1 office) Malaysia (1 office) Myanmar (1 office) Philippines (1 office) Singapore (1 office, 1 regional headquarters) Thailand (1 office) Vietnam (1 office)
Amazon Web Services	United States	IoT software solutions (including managed cloud platform, application infrastructure and middleware, analytics and modeling, and cybersecurity technologies)	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 office, 1 regional headquarters) Thailand (1 office) Viet Nam (1 office)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Continued)

Company	Headquarters	Main activities	Presence in ASEAN
IBM Cloud	United States	IoT software solutions including analytics and modeling, functional applications, and cybersecurity technologies, cloud solutions, databases, analytics, AI, blockchain, integration	Brunei Darussalam (1 office) Indonesia (1 office, channel partners) Malaysia (1 office, channel partners) Philippines (1 office, channel partners) Singapore (1 office, 1 regional headquarters, 1 central hub for IBM's strategic imperatives -- Services Integration Hub, IBM Studios, IBM Garage, IBM Research Lab, and IBM Centre of Blockchain Innovation, AWS partner) Thailand (1 office, channel partners) Viet Nam (1 office, channel partners)
Texas Instruments	United States	IoT hardware solutions (e.g. networks and connectivity, sensors, automation and control)	Malaysia (1 office, 2 manufacturing facilities for semiconductors, sensors, data converters, switches) Philippines (1 office, 2 manufacturing facilities for semiconductor) Viet Nam (2 offices)
C3 IoT	United States	IoT software solutions including cloud computing, analytics, and machine learning	Singapore (office)
NXP Semiconductors	Netherlands	IoT hardware (e.g. processors, sensors) and software solutions including AI	Indonesia (authorized distributors) Malaysia (1 office, 1 manufacturing facility, authorized distributors) Philippines (auhorized distributors) Singapore (1 regional hub; sales/technical and support team for Australia and Southeast Asia ; 1 global distribution centre for Asia; authorized distributors) Thailand (1 office, 1 manufacturing facility) Viet Nam (authorized distributors)
Microsoft	United States	IoT software solutions including cloud, cybersecurity, analytics	Brunei Darussalam (1 office) Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 office, 1 regional headquarters) Thailand (1 office) Viet Nam (1 office)
Micron Technology	United States	IoT hardware solutions including semiconductor chips, edge computing, networking	Malaysia (3 manufacturing facilities) Singapore (4 manufacturing facilities, 1 office, 1 shared service centre for Asia-Pacific region)
Ericsson	Sweden	IoT software solutions (e.g. mobility and broadband technology, 5G technology)	Brunei Darussalam (1 office) Cambodia (1 office) Indonesia (1 office, authorized distributor) Malaysia (1 office, authorized distributor) Philippines 1 (office, authorized distributor) Singapore (1 office, 1 regional headquarters) Thailand (1 office, authorized distributors) Viet Nam (1 office)
Samsung Electronics	Republic of Korea	IoT hardware (e.g. sensor technologies) and software solutions (e.g. connectivity, edge intelligence, AI)	Indonesia (1 office; 1 global R&D institute) Malaysia (1 office) Philippines (office; R&D institute) Singapore (1 office,1 regional headquarters) Thailand (1 office) Viet Nam (1 office, R&D centre for industrial technologies in Southeast Asia, 6 manufacturing facilities)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Continued)

Company	Headquarters	Main activities	Presence in ASEAN
Digi	United States	IoT hardware and software solutions	Singapore (1 office)
Rockwell Automation	United States	IoT hardware (e.g. sensors, automation and control technologies) and software solutions (e.g. networks, connectivity, edge intelligence)	Indonesia, Malaysia, Philippines, Thailand, Viet Nam (1 office respectively for sales, distribution and training functions) Singapore (1 regional hub, 1 manufacturing, 1 office for sales, distribution and training functions) Myanmar (appointed a local distributor/system integrator)
Broadcom	United States	IoT hardware (e.g. processors and sensors) and software solutions (e.g. connectivity, edge intelligence)	Cambodia (authorized distributors) Indonesia (authorized distributors) Malaysia (authorized distributors) Philippines (authorized distributors) Singapore (office coordinating ASEAN sales: Malaysia, Philippines, Singapore, Thailand; authorized distributors) Thailand (authorized distributors) Viet Nam (authorized distributors)
Telefonica	Spain	IoT software solutions (e.g. analytics and modeling, cybersecurity, and networks and connectivity technologies)	Singapore (central hub for Asia Pacific operations)
Mitsubishi Electric	Japan	IoT hardware (e.g. sensors) and software solutions (e.g. AI technology, security technologies)	Malaysia and Thailand (1 office and 1 manufacturing facility each) Indonesia (1 office) Philippines (1 product service centre)
Dell	United States	IoT hardware (e.g. processors) and software solutions (e.g. analytics and modeling, cybersecurity, networks and connectivity)	Brunei Darussalam (authorized distributor) Cambodia (authorized distributor) Indonesia (1 office, authorized distributor) Malaysia (2 manufacturing facilities, 1 office, authorized distributor) Philippines (1 office, authorized distributor) Singapore (1 office, 1 regional headquarters; 1 global innovation facility) Thailand (1 office, authorized distributor) Viet Nam 1 (office, authorized distributor)
Nvidia	United States	IoT hardware solutions (e.g. processors) and software solutions (e.g. edge intelligence technologies)	Singapore (1 office) ; authorized distributors (for Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam)
Qualcomm	United States	IoT hardware solutions (e.g. processors) and software solutions (e.g. analytics and modeling, connectivity and edge intelligence technologies)	Indonesia 1 (office) Singapore (1 office; Asia-Pacific Test Center of Excellence) Viet Nam (2 offices; Southeast Asia R&D facility)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Continued)

Company	Headquarters	Main activities	Presence in ASEAN
Analog Devices	United States	IoT hardware solutions (e.g. data converters, amplifiers and linear products, radio frequency ICs, power management products, sensors)	Cambodia (authorized distributors) Indonesia (authorized distributors) Malaysia (authorized distributors) Philippines (authorized distributors) Singapore (1 office also handling sales in Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam) Thailand (authorized distributors) Viet Nam (authorized distributors)
Ni	United States	Hardware,software, services and systems (e.g. interoperable products and technologies)	Singapore-based distributor covering Brunei Darussalam, Cambodia, Indonesia, Lao People's Demoxratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam) Authorized distributors inside Malaysia, Philippines, Singapore, Thailand, Viet Nam Indonesia (1 office) Malaysia (1 manufacturing facility, 1 R&D centre) Singapore (1 office) Viet Nam (1 office)
GE	United States	IoT hardware (automation and control technologies,) and software solutions (e.g. modeling, analytics, cybersecurity)	Cambodia (1 office) Indonesia (1 country office, 1 manufacturing facility for switchgears) Malaysia (1 regional headquarters, 1 country office, 1 tooling plant) Myanmar (1 office) Philippines (1 country office) Singapore (1 complex manufacturing facility, 1 engineering services, 1 research and customer applications development, 1 regional commercial operations, 1 Asia digital operations centre) Thailand (1 country office) Viet Nam (2 representative offices, 1 subsidiary, 1 manufacturing facility in Hai Phong)
Infineon Technologies	Germany	IoT hardware (e.g. semiconductors, processors, sensors and components) and software solutions (e.g. connectivity, edge intelligence)	Indonesia (1 office, 1 manufacturing facility) Malaysia (3 manufacturing facilities, 1 facility for other functions) Philippines (1 office, 1 R&D centre, 1 facility for other functions) Singapore (1 office, 1 regional headquarters, 1 manufacturing facility, 1 R&D facility) Thailand (1 office that is a subsidiary of the Singapore-based Infineon entity) Viet Nam (1 office that is a subsidiary of the Singapore-based Infineon entity)
AT&T	United States	IoT solutions and platform	Offices (1 in each country: Indonesia, Malaysia, Philippines, Thailand, Viet Nam) Singapore (1 office, 1 regional headquarters)
STMicroelectronics	Switzerland	IoT hardware (e.g. processors, sensors, automation and control, and components) and software solutions (e.g. edge intelligence)	Cambodia (through Singapore-based authorized distributor) Indonesia (1 office that is a subsidiary of STMicroelectronics Singapore; authorized distributors) Lao People's Democratic Republic (through Singapore-based authorized distributor) Malaysia (4 offices, 1 manufacturing facility, authorized distributors) Philippines (1 office, 1 manufacturing facility, authorized distributors) Singapore (5 offices, 1 manufacturing facility, 1 R&D, regional headquarters, authorized distributors) Thailand (2 offices, authorized distributors) Viet Nam (1 office, authorized distributors)
Emerson	United States	IoT hardware (e.g. sensors, automation and control, and actuators) and software solutions (e.g. analytics and modeling, edge intelligence)	Indonesia, Malaysia, Thailand, Viet Nam (1 office each) Philippines (1 regional headquarters) Singapore (1 automation solutions centre, 1 sensing centre of excellence, 1 analytical manufacturing and integration centre, 1 global additive manufacturing centre, 1 manufacturing facility)
Airtel	India	IoT software solution (e.g. network and connectivity solutions)	Singapore (point of presence)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Continued)

Company	Headquarters	Main activities	Presence in ASEAN
Relayr	Germany	IoT hardware solutions (e.g. IoT hardware design and engineering services)	None
Vodafone	United Kingdom	IoT software solution (e.g. networks and connectivity technologies)	Partners (Singapore)
2lemetry (acquired by Amazon Web Services)	United States	IoT software solution (e.g. cloud platforms)	None
Phoenix Contact	Germany	IoT hardware (e.g. sensors, automation and control equipment) and software solutions (e.g. application infrastructure)	Indonesia (sales subsidiary, authorized distributors) Malaysia (sales subsidiary, authorized distributors) Myanmar (sales subsidiary, authorized distributors) Philippines (sales subsidiary, authorized distributors) Singapore (sales subsidiary, regional headquarters for Southeast Asia, authorized distributors) Thailand (sales subsidiary, authorized distributors) Viet Nam (sales subsidiary, authorized distributors)
3M	United States	IoT software solution (e.g. industrial IoT platform)	Indonesia (1 office, authorized distributors) Malaysia (1 office, 1 customer innovation centre, authorized distributors) Philippines (1 office, authorized distributors) Singapore (1 office, 1 customer technical centre, authorized distributors) Thailand (1 office, authorized distributors) Viet Nam (1 office, authorized distributors)
Arm	United Kingdom	IoT hardware (e.g. processors) and software solutions (e.g. analytics and modeling)	Authorized distributors in Malaysia, Philippines, Singapore, Thailand, Viet Nam
Google	United States	IoT software solutions (e.g. Google cloud IoT, analytics and modeling, cybersecurity, cloud computing solutions)	1 office per country (Indonesia, Malaysia, Singapore, Philippine) Cloud partners in Cambodia, Indonesia, Malaysia, Myanmar, Singapore, Thailand, Viet Nam
Eaton	Ireland	IoT hardware (e.g. sensors, and automation and control equipment) and software solution (e.g. connectivity)	Indonesia (1 office) Malaysia (1 office) Philippines (1 office) Singapore (1 office, 1 customer service centre for Southeast Asia) Thailand (1 office) Viet Nam (2 offices)
Accenture	Ireland	IoT software solutions (e.g. IoT cloud planning, design and implementation services, cybersecurity, software design and engineering services)	Indonesia (1 office) Malaysia (1 office; 1 innovation centre) Philippines (1 office) Singapore (1 digital hub including an applied intelligence innovation centre; 1 office) Thailand (1 office)

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Annex table 3.3. Top 50 IIoT MNEs in ASEAN, 2020 (Concluded)

Company	Headquarters	Main activities	Presence in ASEAN
Omron	Japan	IoT hardware solution (e.g. sensor and other IoT equipment)	Indonesia (1 automation centre, 1 manufacturing facility for relays, switches, sockets and sensors) Malaysia (1 manufacturing facility for relays and parts, dies) Philippines (1 office) Singapore (1 regional headquarters, 1 automation centre) Thailand (1 office, 1 automation centre) Viet Nam (1 office)
Ayla Networks	United States	IoT software solutions	NONE (but partners such as AWS, Qualcomm, Microsoft, which have extensive presence in ASEAN)
Juniper Networks	United States	IoT software solutions (e.g. Nokia Bell Lab innovations and other end-to-end solutions for human and machine connections)	NONE (but have partners in its ecosystem in Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam)
Nokia	Finland	IoT software solutions (e.g. networks and connectivity technolgies, analytics and modeling, cybersecurity)	Cambodia (1 office) Indonesia (1 project delivery centre, 1 office) Malaysia (1 office) Myanmar (1 office) Philippines (1 office) Singapore (1 regional headquarters, 1 cloud collaboration hub, 1 office) Thailand (1 office) Viet Nam (1 office)
Hitachi	Japan	IoT hardware (e.g. drones and other equipment) and software solutions (e.g. analytics and modeling, cybersecurity)	Indonesia (2 subsidiaries) Malaysia (2 offices, 1 manufacturing facility which is also a subsidiary) Myanmar (1 office) Philippines (2 offices) Singapore (2 offices, 1 manufacturing facility which is a subsidiary, 1 regional headquarter) Thailand (1 office; 1 regional office overseeing sales in Thailand, Cambodia and Lao People's Democratic Republic; 1 regional smart factory hub, 1 manufacturing facility) Viet Nam (2 representative offices; 1 office; 1 manufacturing facility)

Source: *ASEAN Investment Report 2020–2021* research, based on top 50 ranking by IoTOne (https://www.iotone.com/iotone500) and company websites.
Note: IoT also covers IIoT.

Annex table 3.4. IA and IIoT centres of excellence of MNEs in ASEAN (Selected cases)

Company	Headquarters	Centre of excellence	Location	Year launched	Function	Partnership with
ABB	Switzerland	Customer Innovation Centre (offering digitalization services including IIoT)	Singapore	2019	Showcase to customers how ABB Ability™, the company's comprehensive digital offering, can harness the power of digital to drive progress in operations Work with customers in developing digital solutions Strengthens ABB capacity to serve and support customers in digital transformation	Economic Development Board
		Digital Solutions Centre	Singapore	2018	Develops innovative solutions, information and operational (IT and OT) technologies Application development and support customers with advanced IIoT solutions	
		Robotics Digital Operations Centre	Malaysia	2019	Provides ABB Ability™digital platform, which enables customers to integrate and aggregate data requirements, and apply big data and predictive analytics	InvestKL
		Robotics & Automation Solution Centre	Viet Nam	2018	Acts as a bridge connecting customers' manufacturing goals with ABB's robotics technologies and service support Support customers with advanced manufacturing technologies Serve as a training facility to help lecturers and students of engineering universities gain experience with advanced robotics technologies	Viet Nam Ministry of Science and Technology
Bosch	Germany	Bosch Rexroth Regional Centre (for advanced manufacturing technologies and skills training)	Singapore	2019	Training and talent development for advanced manufacturing companies in Singapore and in the region Delivers and certifies Industry 4.0 specialists following the German IHK standard Collaborates with companies to testbed Industry 4.0 solutions and help clients develop expertise through training use cases	Singapore Polytechnic, SkillsFuture Singapore, Singaporean-German Chamber of Industry and Commerce and Jurong Town Corporation Nanyang Technological University and Jurong Town Corporation. Supports the Nanyang Technological University (NTU)-JTC Industry Talent Development Programme
		R&D Centres	Viet Nam	2014 (first); 2016 (second)	Focuses on software, engineering, computer-aided design, simulations and testing of automotive technologies and fuel injection	..
GE	United States	Asia Digital Operations Centre	Singapore	2017	Work with companies in Asia on digital transformation solutions	SP Group (Singapore)
					Develops capabilities in IIoT and digital intelligent applications. Develop solutions for data analytics and artificial intelligence for clients	Spring Singapore and Platform E
					Supports the GE group's global information technology services and operations	

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Annex table 3.4. IA and IIoT centres of excellence of MNEs in ASEAN (Selected cases) (Continued)

Company	Headquarters	Centre of excellence	Location	Year launched	Function	Partnership with
Honeywell International	United States	Asian Industrial Cyber Security Center	Singapore	2018	Provides industrial manufacturers in the region with cybersecurity solutions Conducts proprietary research, develop new security technologies, provide training and certifications, and test and validate actual solutions deployed at customer plants	Economic Development Board
					Research and development laboratory Delivers managed security services to help customers	
Microsoft	United States	Asia Experience Center	Singapore	2019	Provides companies with access to digital technologies and innovations. Offers four types of experience solutions: (i) the Experience Zone for demonstrations and new technologies; (ii) the Microsoft Technology Centre for facility-based technical engagements; (iii) the Cybersecurity Centre for threat intelligence analytics and security; and (iv) the Innovation Factory for ideation, innovative ideas, and hackathons	..
NXP Semiconductors	Netherlands	Global headquarters for standard products and operations, Global distribution centre for Asia logistics strategy Corporate research and development laboratory	Singapore	2013	Helps NXP get closer to the growing base of potential customers Establishes a base for further growth in the region	Nanyang Technological University, Singapore
				2012	Develops next-generation technologies, including security chips used in biometric passports and automotive sensors	
Omron	Japan	Omron Automation Centers	Indonesia, Thailand	Thailand (2015), Indonesia (2016)	Industrial automation plant (producing components for Omron's businesses in industrial automation, automotive electronics, and electronic and mechanical components) Showroom that focuses on how AI, IIoT and robots can be used in manufacturing for automotive, electronics and health care	Economic Development Board
			Singapore	2017	Innovation showroom-cum-research and development in robotics technology Helps to drive tadoption of integrated automation solutions and robotic applications, particularly among the SMEs Identify solutions for manufacturing clients in adoption of advanced artificial intelligence, IIoT, and robotics technology Offers clients with OMRON's Smart and Future Factory experience, and the Future CEO Cockpit, which showcase how a new level of manufacturing intelligence and operational visibility can be attained by leveraging on disruptive technologies	Economic Development Board
Rockwell Automation	United States	Connected Services Experience Centre	Singapore, Indonesia, Malaysia, Thailand	2019 (Singapore)	Demonstrates integration of technology platforms for IT and OT convergence. The centre offers customers the benefits of connected enterprises through deployment of digital technologies	..

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Annex table 3.4. IA and IIoT centres of excellence of MNEs in ASEAN (Selected cases) (Concluded)

Company	Headquarters	Centre of excellence	Location	Year launched	Function	Partnership with
Schneider Electric	France	Smart factories	Batam, Indonesia	2018	Factory use case and also provides demonstration to customers deployment of a range of IIoT technologies and other digital tools such as virtual and augmented reality	Industry Research and Development Agency of the Ministry of Industry (Indonesia)
			Philippines	2019	Showcase facility for customers implementing IIoT technology to see how EcoStruxure™ industry solutions provide real-time tracking of performance in smart factory operation	Ministry of Education and Culture
					Showcases EcoStruxure™ to clients and benefits that can be gained from increased productivity and efficiency	..
Siemens	Germany	Advanced Manufacturing Transformation Centre	Singapore	2020	Bridges the gap between prototyping and industrial production of additive manufacturing to support clients in digital transformation Supports clients in developing advance manufacturing plants with creation of a digital 'twin' Gives customers hands-on exposure to an end-to-end additive manufacturing production line Provides customers access to high-end industrial design software and 3D printers, as well as post-processing equipment, low-volume 3D printing for prototyping and testing, before deciding to invest in additive manufacturing production lines	Singapore Agency for Science, Technology and Research (A*STAR), EOS, HP, Singapore Polytechnic, Technical University of Munich, and Ultimaker
Yamazaki Mazak	Japan	Smart factory	Singapore	2017	Provides automation and AI experience and connectivity between devices, which allows real-time communication between the office and factory	Economic Development Board
Yamazaki Mazak	Japan	Robotic Centre	Indonesia	2014	Provides clients with the experience and benefits in deployment of industrial robots, servos and drives. Also, a venue for training in automation	..
		Renovation and expansion of robotic centre	Thailand	2015	A facility where customers and system integrators could examine and verify ways of utilizing robots in industrial production; also, a training facility in automation	..

Source: ASEAN Investment Report 2020–2021 research, based on annex tables 3.1 and 3.3, company websites and annual reports.

Annex table 3.5. Foreign-owned smart factories in ASEAN (Selected cases)

Company	Nationality	Activity	Location in ASEAN	Advanced manufacturing and Industry 4.0 technologies adopted
ABB	Switzerland	High-voltage component factory	Viet Nam	Automation, IIoT, AI and data analytics for real-time information on the manufacturing process and to trace sources of materials of all products through the systems Smart sensors to monitor the performance of ABB robot motors and temperature or vibration control Other technologies to support remote monitoring; e.g. IIoT technology for making data readily available for monitoring solar plant
Acecook	Japan	Instant noodles production	Viet Nam	Automation, IIoT, data analytics Mixed use of devices such as digital tachographs, and smart devices (smartphones) Software that can collect vehicle-sensor data (such as speed, fuel consumption and temperature)
Afton	United States	Chemical manufacturing	Singapore	Advanced automation with remote machine-human interface, IIoT, data science and analytics
Amgen	United States	Biologics medicine manufacturing	Singapore	Automation and integration of all systems into a single enterprise data lake IIoT, AI, real-time use of big data for analytics and other applications Structured data integration and analytics platform combined with predictive modelling and visualization to enable centralized process monitoring across entire manufacturing network
Asmo	Japan	Automotive parts	Indonesia	Deployed Omron (Japan) IA solution, sensor, IIoT and other digital hardware and software
Astra International	Hong Kong, China	Automotive production	Indonesia	Automation and a combination of interconnected Industry 4.0 technologies
Benchmark Electronics	United States	Electronics OEM	Thailand	Advanced automation and robotic technology (collaborative robots with IIoT), AI and real-time control facilities
Bosch	Germany	Automotive parts manufacturing	Thailand	Advanced automation technologies, IIoT, AI and data analytics in R&D centre at Bosch Mobility Solutions, a smart factory for injection technology that is a connected manufacturing facility Sensors embedded in manufacturing machines to collect data on operational status and performance and internet-connected machinery to monitor the overall production process; brings together a wide range of information in real time
			Malaysia	Cyberphysical systems integrated into manufacturing technologies using sensors, IIoT gateway, software, robots and active assist system to convert plant into a smart factory Automation, IIoT, and data analytics in conversion of Dong Nai plant to a smart connected factory
			Viet Nam	A laboratory for smart cities and Industry 4.0 solutions at the Bosch Software and Engineering R&D Centre for an IoT solution hub
Brose	Germany	Automotive parts manufacturing (door systems and window regulators)	Thailand	Automation and innovative robotic technology (intelligent robots), connectivity, IIoT, AI real-time monitoring of products across production line

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Annex table 3.5. Foreign-owned smart factories in ASEAN (Selected cases) (Continued)

Company	Nationality	Activity	Location in ASEAN	Advanced manufacturing and Industry 4.0 technologies adopted
Chevron Oronite	United States	Lubricant additives manufacturing	Singapore	Integration automation and IIoT Plant-wide wireless infrastructure (ranging from process equipment and field instruments to mobile devices for staff) to enhance the overall connectivity of the facility AI to build predictive models for anticipating equipment failure
Clarion	Japan	Automotive electric system parts manufacturing	Thailand	Connected and intelligent automation
Coherent	United States	Industrial laser systems and components manufacturing	Singapore	Advanced automation technologies and integration, IIoT and AI (implementation of lean digitalization transformation map)
Denka Chemicals	Japan	Chemical manufacturing	Singapore	Advanced automation technologies, connected system, IIoT for steam traps and for monitoring the chemical plant, AI for predictive data analysis
Dyson	United Kingdom	Motor manufacturing for household appliances	Singapore	Advanced automation and robotic technologies, IIoT, real-time control and data availability at any stage of the production process, AI and data analytics
Feinmetall	Germany	Design and manufacturing of wafer probe cards for semiconductor wafer tests	Singapore	Advanced manufacturing technologies with high integration of automation and IIoT for connectivity and data flow AI and data analytics to analyse machine data, develop measures to minimize stoppage and plan machine maintenance schedules
Fujitsu	Japan	Electronics, computing equipment, storage, server, integrated system	Indonesia	A combination of interconnected Industry 4.0 technologies
GE	United States	Manufacturing of components for other GE businesses	Viet Nam	All machines in the factory connected through Industry 4.0 solutions and IoT; additive manufacturing, augmented reality and virtual reality deployed in the factory
Hanon Systems	Republic of Korea	Automotive parts manufacturing	Thailand	Innovative advanced technology involving automated, connected, digitized and intelligent technologies
Hitachi Automotive Systems Chonburi	Japan	Automotive parts manufacturing	Thailand	Advanced automation technologies: Automation, IIoT, data analytics and AI
Hitachi Industrial Equipment	Japan	Air compressor manufacturing	Malaysia	Integrated manufacturing technology solution comprising automation, IIoT, data analytics and AI
Hyundai Indonesia	Republic of Korea	Automotive manufacturing	Indonesia	Advanced manufacturing technologies such as advanced IA and robotics technology, IIoT, data analytics and AI in new assembly plant that will be able to automatically recognize car types and specs, inspect factory equipment in real time and conduct preventive diagnosis

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Annex table 3.5. Foreign-owned smart factories in ASEAN (Selected cases) (Continued)

Company	Nationality	Activity	Location in ASEAN	Advanced manufacturing and Industry 4.0 technologies adopted
Infineon Technologies	Germany	Semiconductor fabrication	Singapore	Digital, horizontal and vertical integration and connectivity of manufacturing value chain, implementing Industry 4.0 technologies at backend manufacturing plant Investment cost: about $79 million
Jinpao Precision Industry	Taiwan Province of China	Electronics and tools for precision engineering	Thailand	Integrated manufacturing system involving automation, IIoT, data analytics, AI and predictive maintenance technologies
Makino Asia	Japan	Precision engineering manufacturing	Singapore	Smart factory designed with Industry 4.0 technologies (advanced automation, robotics technologies, IIoT, AI, data analytics and augmented reality) Estimated $71 million investment since 2016
Micron Technology	United States	Solid-state device assembly and test (semiconductor fabrication)	Malaysia	Advanced automation, preventive maintenance, IIoT and AI at centre of excellence to open in 2021
		Semiconductor fabrication	Singapore	Automation, preventive maintenance, IIoT, AI for advanced analytics Deep-learning optical-defect detection Integated deviation management platform
Nissan	Japan	Automotive manufacturing	Thailand	Collaborative robotic technology, intelligent and advanced automation technology, which includes IIoT, data analytics, AI application
Omron	Japan	IA, electronic components, solar power, health care equipment	Indonesia	Automation and a combination of interconnected Industry 4.0 technologies
Panasonic	Japan	Electronics production	Indonesia	IA, sensor, IIoT and other digital hardware and software. Solutions provided by Omron (Japan)
Pepperl+Fuchs	Germany	Automation and sensor technology manufacturing	Singapore	Advanced automation, IIoT, AI and automated guided vehicles, which automate the moving of both raw materials and finished goods between storage and the production lines at a global distribution centre that includes manufacturing operations
Prinx Chengshan Tire (Thailand)	China	Tire manufacturing	Thailand	Intelligent manufacturing facility (interconnected, automated, advanced information platform, intelligent monitoring, traceability, data analysis and maintenance in production process)
ScanCom	Denmark	Outdoor furniture and plastic manufacturing	Viet Nam	Automation and robotics technology, IIoT for connected manufacturing system and data analytics
Schneider Electric	France	Manufacturing of power and IA products	Indonesia (Batam)	Smart factory involving automation, integrating big data, cloud and a range of IIoT technologies Other digital facilities such as virtual and augmented reality Open, interoperable architecture and platform for real-time tracking of performance, operations and machinery, and preventive maintenance
		Manufacturing of power and IA products	Philippines	Automation, IIoT, digitization, interoperable platform connecting products, edge control and applications of analytics and other digital solutions
		Manufacturing of high-technology electronic products	Viet Nam	Automation, IIoT, connectivity solutions and data analytics

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Annex table 3.5. Foreign-owned smart factories in ASEAN (Selected cases) (Concluded)

Company	Nationality	Activity	Location in ASEAN	Advanced manufacturing and Industry 4.0 technologies adopted
SGMW Motor Indonesia	China	Automotive and parts production	Indonesia	IA and a combination of interconnected Industry 4.0 technologies Deployed Fanuc (Japan) robotics welding solution
Shell	Netherlands	Petrochemical manufacturing	Singapore	A digital twin of the Pulau Bukom petrochemical manufacturing site with advanced automation, IIoT, AI, big data and data analytics technologies Augmented and virtual reality to provide live information on plant operations to engineers
Siemens	Germany	Various industrial activities and Industry 4.0 technology solution providers	Indonesia	A combination of Industry 4.0 technologies, automation, operator control and monitoring systems
Jinpao Precision Industry	Taiwan Province of China	Semiconductor fabrication	Singapore	Advanced automation, robotics technology, IIoT, data analytics and AI that allow analysis of incoming manufacturing data, including fault detection and classification solutions in real time
		Semiconductor fabrication (for automotive, computing, wireless telecommunication)	Malaysia	Full IA, IIoT, data analytics
Sumitomo Chemicals	Japan	Chemical manufacturing	Singapore	Digitalization of plant-related operations and visualization and upgrading of global supply chain information in a global IoT project, supported by EDB and in cooperation with Accenture The expertise acquired to be a reference for the roll-out of IIoT technology to its plants around the world
Suzuki	Japan	Automotive production	Indonesia	Automation, sensors, control and smart production system
Systems on Silicon Manufacturing Company (joint venture of NXP Semiconductor and Taiwan Semiconductor Manufacturing Company)	Netherlands-Taiwan Province of China	Automotive and specialty chip manufacturing	Singapore	Upgraded factory automation, robots, IIoT and other digital solutions
TMMIN (Toyota Indonesia)	Japan	Automotive manufacturing	Indonesia	Advanced automation and robotic technologies, IIoT, blockchain, predictive maintenance, supply chain traceability and data analytics
Yamazaki Mazak	Japan	Machine tool manufacturing	Singapore	Advanced automation technologies, IIoT, AI and connectivity between devices, which allows real-time communication between the office and factory
Yokogawa Engineering Asia	Japan	Electric manufacturing	Singapore	High automation, IIoT and big data analytics in manufacturing facility that is part of the company's centre of excellence, part of which is its Global IIoT Co-Innovation Centre

Source: *ASEAN Investment Report 2021–2021* research, based on government and company websites, consultancy reports and media.
Note: Companies listed have adopted a minimum of three Industry 4.0 technologies, such as advanced IA and robots, IIoT, AI and data analytics enabled by machine-to-machine interaction, remote real-time data accessibility and predictive maintenance, and full connectivity with smart factory systems.

Annex table 3.6. ASEAN firms adopting smart factory technologies supplied by MNEs (Selected cases)

Company	Nationality	Activity	Location in ASEAN	Industry 4.0 technologies
Asia Pacific Rayon	Indonesia	Viscose rayon production	Indonesia	Digitization, automation, IIoT and big data technology
Chandra Asri Petrochemical	Indonesia	Petrochemical manufacturing	Indonesia	Digital twin for a smart factory in the Chandra Asri Petrochemical Complex being installed by Siemens AG (Germany) and Bentley Systems (United States) to be completed by 2025
Garuda Food	Indonesia	Chocolate production	Indonesia	Totally integrated automation, IIoT, AI, data analytics technology provided by Siemens (Germany) Real-time monitoring and control of production process that can be conducted from anywhere with a connected device
Greenfields Indonesia	Indonesia	Dairy production (milk)	Indonesia	Automation, IIoT, AI, data analytics and predictive maintenance technology
Indolakto Purwosari	Indonesia	Dairy production (milk)	Indonesia	Digitization, automation (advanced robotics), IIoT, AI, data analytics technology that enables remote access to and control of factory operations
Kalbe Morinaga Indonesia	Indonesia	Nutritional supplement manufacturing	Indonesia	Full advanced automation, IIoT, AI, data analytics technology, including predictive maintenance, real-time information on production operations
Pupuk Kalimantan Timur	Indonesia	Fertilizer manufacturing	Indonesia	Digitization, automation, IIoT, AI and data analytics
Sritex	Indonesia	Textile production	Indonesia	Automation, robotic systems, digitalization, additive manufacturing, IIoT, data analytics and other technology connectivity
Nationgate Solution	Malaysia	Electronics manufacturing and final testing service	Malaysia	Automation, IIoT, AI, big data analytics and preventive maintenance technology
Pentamaster	Malaysia	Automated equipment manufacturing	Malaysia	IA, autonomous robotic technology, IIoT and big data analytics
Vitrox Technology	Malaysia	Electronics design and manufacturing	Malaysia	Automation, systems integration, IIoT and AI technologies
Kulicke & Sofa	Singapore	Electronics manufacturing and solutions	Singapore	IIoT, AI, big data, cloud computing and advanced sensors
People Bee Hoon	Singapore	Food production	Singapore	Automation, connectivity system, IIoT, AI and big data analytics
Siam City Cement	Thailand	Cement manufacturing	Thailand	Automation, IIoT, machine learning, predictive analytics, remote real-time tracking technology, with smart connected factory technology provided by Fujitsu (Japan)
Asia Cement Pukrang Plant	Thailand	Cement manufacturing	Thailand	Advanced automation, IIoT, machine connectivity, AI, data analytics and predictive maintenance technologies
Truong Hai Auto	Viet Nam	Automotive manufacturing	Viet Nam	Automation (factory-wide), robotic technology, digital platform and integration system, IIoT, AI and data analytics in facilities of the entire value chain from ordering to production

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Annex table 3.6. ASEAN firms adopting smart factory technologies supplied by MNEs (Selected cases) (Concluded)

Company	Nationality	Activity	Location in ASEAN	Industry 4.0 technologies
Vietnam Soybean Milk Company	Viet Nam	Soymilk production	Viet Nam	Advanced automation technology, robots, IIoT, AI and data analytics, with technology solutions provided by Tetra Pak (Sweden) and ABB (Switzerland)
Vinacomin Motor Industries	Viet Nam	Manufacturing of spare parts for mining trucks	Viet Nam	Industrial and connected automation systems, advanced robotic technology (collaborative robots), IIoT and AI technologies
Vinamilk	Viet Nam	Dairy production	Viet Nam	Advanced automation, robotic technologies, unmanned laser-guided vehicles, IIoT, AI, data analytics, remote data accessibility, predictive maintenance and full traceability of products
VinFast	Viet Nam	Automotive manufacturing	Viet Nam	Manufacturing complex: advanced automation and robotic technology, IIoT and cloud computing, AI, data analytics, technology connectivity of five factories, remote control through connected device Welding plant: about 1,200 robots, fully automated Robots from ABB (Switzerland), tooling solution from Norgren (United Kingdom), closed-loop manufacturing system, which uses digital twins of products and production, supplied by Siemens (Germany)

Source: ASEAN Investment Report 2020–2021 research, based on government and company websites, consultancy reports and media.

Annex table 4.1. Top 50 start-ups in ASEAN, as of May 2021

Rank	Start-up	Activity/business	Headquarters	Presence in ASEAN	Top five investors	Total funding ($ million)
1	Tokopedia	E-commerce, internet, marketplace, shopping	Indonesia	Indonesia	Alibaba Group (China), SoftBank Vision Fund (United Kingdom), Sequoia Capital India (India), East Ventures (Japan), Softbank Ventures Asia (Republic of Korea)	2 800
2	Bukalapak	E-commerce, e-commerce platforms, internet, online portals	Indonesia	Indonesia	Ant Group (China), Naver (Republic of Korea), Microsoft (United States), 500 Startups (United States), GIC (Singapore)	784
3	Moglix	E-commerce, marketplace for industrial equipment and business supplies, mobile	Singapore	Singapore, outside ASEAN	Sequoia Capital India (India), Tiger Global Management (United States) Accel (United States), International Finance Corporation (United States), Bessemer Venture Partners (United States)	222
4	Gojek	Consumer applications, food delivery, logistics, payments, transportation	Indonesia	Indonesia, Thailand, Singapore, Viet Nam	Facebook (United States), Tencent (China), Meituan (China), DST Global (Hong Kong, China), Temasek Holdings (Singapore)	5 293
5	BukuKas	Apps, financial services, fintech, internet	Indonesia	Indonesia (plans to expand in ASEAN)	Sequoia Capital India (India), Endeavor Catalyst (United States), Speedinvest (Austria), Gokul Rajaram (individual), Surge (Singapore)	69
6	TaniHub (289)	Agriculture, B2B, e-commerce, farming, marketplace	Indonesia	Indonesia, Singapore, outside ASEAN	MDI Ventures (Indonesia), Vertex Ventures (United States), Openspace Ventures (Singapore), Alpha JWC Ventures (Indonesia), Flourish Ventures (United States)	94
7	Nium	Finance, financial services, fintech	Singapore	Singapore, Indonesia, Malaysia, outside ASEAN	Ripple (United States), MDI Ventures (Indonesia), Temasek Holdings (Singapore), Visa, (Singapore), Vertex Ventures (United States)	80
8	StashAway	Financial services, personal finance, wealth management	Singapore	Singapore, Malaysia, outside ASEAN	Sequoia Capital India (India), Eight Roads Ventures (United Kingdom), Fidelity International (United Kingdom), Square Peg Capital (Australia), Burda Principal Investments (Germany)	61
9	Thunes	Financial services, fintech, mobile payments, payments	Singapore	Singapore, partnership with True Money (Thailand) to cover markets in Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Viet Nam	Checkout.com (United Kingdom), GGV Capital (United States), Insight Partners (United States), Future Shape (France), Helios Investment Partners (United Kingdom)	130
10	Halodoc	Health care, medical, mobile apps, pharmaceutical	Indonesia	Indonesia	Temasek Holdings (Singapore), Gojek (Indonesia), WuXi AppTec (China), Novo Holdings (Denmark), Bill & Melinda Gates Foundation (United States)	145
11	Trax	Analytics, computer vision, e-commerce, image recognition, retail technology	Singapore	Singapore, outside ASEAN	BlackRock (United States), SoftBank Vision Fund (United Kingdom), Sony Innovation Fund (Japan), Investec (South Africa), Warburg Pincus (United States)	1 027
12	Torum	Cryptocurrency, mobile apps, social media, social network	Malaysia	Malaysia	AU21 Capital (United States), Momentum 6 (United States), Consensus Lab (China), IDC Ventures (Spain), Waterdrip Capital (China)	3
13	Fave	Advertising platforms, digital marketing, e-commerce, financial services, mobile payments, retail	Singapore	Singapore, Indonesia, Malaysia, outside ASEAN	Pine Labs (India), Sequoia Capital (United States), Sequoia Capital India (India), SIG China (SIG Asia Investments) (China), InnoVen Capital (China)	32

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Annex table 4.1. Top 50 start-ups in ASEAN, as of May 2021 (Continued)

Rank	Start-up	Activity/business	Headquarters	Presence in ASEAN	Top five investors	Total funding ($ million)
14	Traveloka	Big data, inflight entertainment, search engine, travel	Indonesia	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	Sequoia Capital (United States), East Ventures (Japan), GIC (Singapore), JD.com (China), Global Founders Capital (Germany)	1 170
15	LongHash Ventures	Financial services, information technology, internet	Singapore	Singapore, outside ASEAN	Fenbushi Capital (China), HashKey Capital (Hong Kong, China)	2
16	Axie Infinity	Blockchain, video games	Viet Nam	Viet Nam	ConsenSys (Switzerland), Animoca Brands (Hong Kong, China), 500 Startups (United States), Hashed (Republic of Korea), Libertus Capital (United Kingdom)	9
17	Hummingbird Bioscience	Biotechnology, health care, therapeutics	Singapore	Singapore, outside ASEAN	Altrium Capital Management, Novo Holdings (Denmark), Polaris Partners (United States), Decheng Capital (United States), Ally Bridge Group (Hong Kong, China)	150
18	Una Brands	E-commerce, retail	Singapore	Singapore, Indonesia, Malaysia, outside ASEAN	500 Startups (United States), Global Founders Capital (Germany), 468 Capital, Kingsway Capital (United Kingdom), Maximilian Bittner (Individual)	40
19	Shipper	Delivery, e-commerce, internet, logistics	Indonesia	Indonesia	Lightspeed Venture Partners (United States), DST Global (Hong Kong, China), Sequoia Capital India (India), Prosus Ventures (South Africa), Y Combinator (United States)	88
20	Carousell	Classifieds, consumer goods, e-commerce, marketplace, mobile apps	Singapore	Singapore, Indonesia, Malaysia, Philippines, outside ASEAN	Naver (Republic of Korea), Rakuten (Japan), Sequoia Capital India (India), 500 Startups (United States), Quest Ventures (Singapore)	178
21	Ruangguru	Edtech, education, training	Indonesia	Indonesia	GGV Capital (United States), General Atlantic (United States), East Ventures (Japan), Tiger Global Management (United States), UOB Venture (Singapore)	205
22	Sea	E-commerce, messaging, mobile, payments	Singapore	Singapore, Indonesia, Philippines, Thailand, Viet Nam	Tencent (China), General Atlantic (United States), Ontario Teachers' Pension Plan (Canada), Hillhouse Capital Group (China), Farallon Capital Management (United States)	2 647
23	NextBillion.ai	AI, information technology, machine learning, mapping services, software	Singapore	Singapore, outside ASEAN	Falcon Edge Capital (United States), M12 (United States), Lightspeed India Partners (India), Prashant Malik (Individual), Ashwini Asokan (Individual)	13
24	Validus	Financial services, fintech, lending	Singapore	Singapore, Indonesia, Viet Nam, Thailand	Vertex Ventures (United States), FMO (Netherlands), Openspace Ventures (Singapore), Vertex Growth Fund (Singapore), AddVentures by SCG (Thailand)	82
25	Ula	Apps, B2B, e-commerce, marketplace	Indonesia	Indonesia	Sequoia Capital India (India), B Capital Group (United States), Sujeet Kumar (individual), Lightspeed India Partners (India), Saison Capital (Singapore)	30
26	Grab	Car sharing, financial services, food delivery, ride sharing, transportation	Singapore	Indonesia, Cambodia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	SoftBank (Japan), SoftBank Vision Fund (United Kingdom), Lightspeed Venture Partners (United States), GGV Capital (United States), Invesco (United States)	12 148

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Annex table 4.1. Top 50 start-ups in ASEAN, as of May 2021 (Continued)

Rank	Start-up	Activity/business	Headquarters	Presence in ASEAN	Top five investors	Total funding ($ million)
27	GreyOrange	Hardware, industrial automation, logistics, robotics, software	Singapore	Singapore, outside ASEAN	Flipkart (India), Tiger Global Management (United States), Mithril Capital Management (United States), InnoVen Capital (India), Rajesh Sawhney (Individual)	170
28	Ajaib	Finance, financial services, fintech, trading platform	Indonesia	Indonesia	Ribbit Capital (United States), Y Combinator (United States), Horizons Ventures (Hong Kong, China), Insignia Ventures Partners (Singapore), Softbank Ventures Asia (Republic of Korea)	92
29	PatSnap	Analytics, AI, business intelligence	Singapore	Singapore, outside ASEAN	Tencent (China), SoftBank Vision Fund (United Kingdom), Temasek Holdings (Singapore), Sequoia Capital China (China), Vertex Ventures (Singapore)	352
30	Near	Analytics, AI, location based services, marketing, SaaS	Singapore	Singapore, outside ASEAN	OurCrowd (Israel), Sequoia Capital India (India), Canaan Partners (United States), Global Brain Corporation (Japan), Cisco (United States)	134
31	Sirclo	E-commerce, e-commerce platforms, SaaS, sales	Indonesia	Indonesia	East Ventures (Japan), Google Launchpad Accelerator (United States), SMDV (Indonesia), Skystar Capital (Indonesia), Sinar Mas Land (Indonesia)	56
32	Enjin	Content, cryptocurrency, identity management, video games	Singapore	Singapore	BlockTower Capital (United States), Arrington XRP Capital (United States), Fenbushi Capital (China), ICONIUM (Italy), Hashed (Republic of Korea)	42
33	Bibit.Id	Financial services, fintech, information technology, IoT	Indonesia	Indonesia	Tencent (China), Sequoia Capital India (India), East Ventures (Japan), Prosus Ventures (South Africa), 500 Startups (United States)	95
34	Kucoin	Bitcoin, blockchain, cryptocurrency, finance, financial exchanges	Singapore	Singapore, Viet Nam, outside ASEAN	Matrix Partners (United States), IDG Capital (China), NEO Global Capital (Singapore), Karnika Yashwant (Individual)	20
35	LinkAja	Financial services, fintech	Indonesia	Indonesia	Gojek (Indonesia), Grab (Singapore), Telkomsel (Indonesia), Mandiri Capital Indonesia (Indonesia) (MCI), BRI Ventures (Indonesia)	100
36	Qtum	Blockchain, cryptocurrency, ethereum	Singapore	Singapore	Hashed (Republic of Korea), Crypto Chan (Individual), Eden Block (Israel), Jeremy Gardner (Individual), Distributed Global (United States)	17
37	Emeritus	Education, higher education	Singapore	Singapore, outside ASEAN	Sequoia Capital India (India), Bertelsmann India Investments (Netherlands)	40
38	QueQ	Apps, lifestyle, search engine	Thailand	Thailand, Malaysia, outside ASEAN	Bon Angels Venture Partners (Republic of Korea), Google Launchpad Accelerator (United States), True Incube (Thailand)	3
39	Xendit	Banking, finance, financial services, fintech, payments	Indonesia	Indonesia, Philippines	East Ventures (Japan), Y Combinator (United States), Accel (United States), Golden Gate (Singapore), Berkeley SkyDeck (United States)	65
40	Glints	Employment, human resources, online portals, recruitment	Singapore	Singapore, Indonesia, Viet Nam, outside ASEAN	East Ventures (Japan), 500 Startups (United States), Monk's Hill Ventures (Singapore), Golden Equator Ventures (Singapore), Wavemaker Partners (Singapore)	32

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Annex table 4.1. Top 50 start-ups in ASEAN, as of May 2021 (Concluded)

Rank	Start-up	Activity/business	Headquarters	Presence in ASEAN	Top five investors	Total funding ($ million)
41	CoLearn	Edtech, education, information technology	Indonesia	Indonesia	GSV Ventures (United States), AC Ventures (Indonesia), Alpha JWC Ventures (Indonesia), Surge (Singapore), Alpha Wave Incubation (managed by Falcon Edge (United States))	10
42	GoBear	Auto insurance, financial services, health insurance, insurtech, internet, price comparison[a]	Singapore	Singapore	Aegon (Netherlands), Walvis Participaties (Netherlands)	97
43	Amartha	Financial services, fintech	Indonesia	Indonesia	MDI Ventures, (Indonesia), BEENEXT (Singapore), Lendable (Kenya), Bank Mandiri (Indonesia), UOB Venture (Singapore	56
44	PropertyGuru	E-commerce, mobile apps, online portals, real estate, rental property	Singapore	Singapore, Indonesia, Malaysia, Thailand, Viet Nam	Emtek Group (Indonesia), TPG, Kohlberg Kravis Roberts (United States), Square Peg Capital (United States), ImmobilienScout 24 (Germany)	536
45	Lazada	E- fashion, internet, shopping[b]	Singapore	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	Alibaba Group (China), Temasek Holdings (Singapore), Rocket Internet (Germany), HV Capital (Germany), Kinnevik (Sweden)	4 210
46	Vingroup	Finance, property management, real estate, real estate investment	Viet Nam	Viet Nam	GIC (Singapore), Credit Suisse (Switzerland), SK Group (Republic of Korea)	1 900
47	Finlync	Accounting, enterprise resource planning, finance, fintech	Singapore	Singapore, outside ASEAN	Nyca Partners (United States), Point72 Ventures (United States), William Hockey (Individual), Vine Ventures (United States), Colin Anderson (Individual)	16
48	Carro	Automotive, e-commerce, e-commerce platforms, leasing, marketplace	Singapore	Singapore, Indonesia, Thailand	B Capital Group (United States), Quest Ventures (Singapore), Insignia Ventures Partners (Singapore), Softbank Ventures Asia (Republic of Korea), Alpha JWC Ventures (Indonesia)	229
49	IPrice	E-commerce, shopping	Malaysia	Malaysia, Indonesia, Philippines, Singapore, Thailand, Viet Nam, outside ASEAN	Naver (Republic of Korea), Rocket Internet (Germany), 500 Startups (United States), Lazada Group (Singapore), Woowa Bros (Republic of Korea)	21
50	Tribe Accelerator	Automotive, blockchain, information technology, Insurtech, logistics, supply chain management	Singapore	Singapore	Twitter (United States), Coinbase (United States), Korea Investment Partners (Republic of Korea), SGInnovate (Singapore), Greg Kidd (individual)	86

Source: Crunchbase.

Note: Based on the ranking methodology of Crunchbase, which uses algorithms to score and rank entities. The algorithms consider a range of variables, from total funding amount, relationships with other entities in the Crunchbase platform and the number of times the entity has been viewed in Crunchbase (https://support.crunchbase.com/hc/en-us/articles/115010477187-Crunchbase-Rank-CB-Rank-).

[a] In April 2021, Finder Australia acquired GoBear.

[b] In 2016, Lazada became the Southeast Asia flagship of the Alibaba Group.

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