ACCELERATING DIGITAL TRANSFORMATION IN INDONESIA:

Technology, Market, and Policy

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ERIA

Accelerating Digital Transformation in Indonesia: Technology, Market, and Policy

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FOREWORD

The world has witnessed various technological advances that have revolutionised production methods, business organisation, and the way people work and live. Countries both in the North and the South are facing opportunities and challenges from a new wave of a technological revolution driven by progress in information and communication technology, complemented by new sources of energy and new types of materials. New technologies and high-tech-enabled business models have huge implications for development – both economically and socially.

Globally, the development of the digital economy has been integral to the achievement of the United Nations Sustainable Development Goals. The ASEAN Economic Community Blueprint 2025 (AEC 2025) highlights the importance of incorporating economic digitalisation in regional development. Digital integration is also important in contributing to the success of the AEC 2025 Consolidated Strategic Action Plan. Broadly speaking, digital transformation will help the region achieve the five objectives defined in the ASEAN Socio-Cultural Community Blueprint 2025: (i) human development, (ii) social welfare and protection, (iii) social justice and rights, (iv) ensuring environmental sustainability, and (v) building ASEAN identity.

Countries in the Association of Southeast Asian Nations (ASEAN) and East Asia have made remarkable progress in economic development. Whether the region can continue its rapid growth will to a great extent depend on how well it manages the digital transformation. An in-depth understanding of regional and national advantages and disadvantages, when faced with challenges from digitalisation, will help smooth the digital transformation and unleash Asia's development potential in the digital era. In this context, the Economic Research Institute for ASEAN and East Asia (ERIA) has undertaken a series of policy-oriented research projects on the digital economy.

The current volume, *Accelerating Digital Transformation in Indonesia* – prepared by Lurong Chen, Kalamullah Ramli, Fithra Faisal Hastiadi, and Muhammad Suryanegara – provides policy recommendations, from a country perspective, on how to accelerate the pace of digital transformation with a balance between efficiency and inclusiveness, and in the long term, how to synchronise the interaction amongst digitalisation, competition, innovation, and human development in Asian development.

Hidetoshi Nishimura
President
Economic Research Institute for ASEAN and East Asia (ERIA)

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This book is the first volume of an Economic Research Institute for ASEAN and East Asia (ERIA) series on Accelerating Digital Transformation in Asia. The ERIA research project shares in-depth understanding of the Association of Southeast Asian Nations (ASEAN) Member States' advantages and disadvantages, as well as those of the region, to help ease ASEAN through the digital transformation and fully unleash its development potential in the digital era. This volume provides insights on the progress of digital transformation in Indonesia, as well as policy recommendations on (i) how to accelerate the pace of this transformation, considering both efficiency and inclusiveness; and (ii) in the long term, how digitalisation, competition, innovation, and human development interact.

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INTRODUCTION

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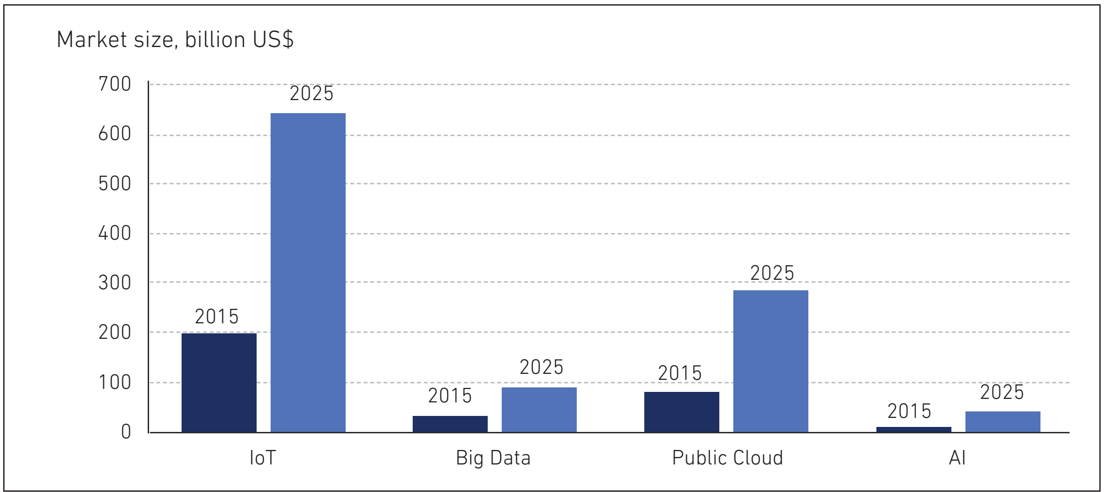
Digital technology has been one of the major transformational forces of human society, fuelling great prosperity in the world economy. Digital transformation can be seen as the transition from a classic organisation that relies on real-world resources to a digital organisation that relies on information and virtual resources (Delgado, 2017). This includes (i) changing organisational processes and culture (Iljins, Skvarciany, and Gaile-Sarkane, 2015); (ii) enabling and optimising the use of information and communication technology (ICT) to improve public service (Meijer and Bekkers, 2015); and (iii) new value-added creation. Countries around the world are rushing to harness opportunities induced by digitalisation. Globally, development of the digital economy has been an integral component of the United Nations Sustainable Development Goals. At the World Economic Forum Annual Meeting in May 2022, leaders from around the world agreed that technology would be key to meeting the Sustainable Development Goals.

ICT is a pervasive technology that has the potential to radically change the foundation of our society (Mansell and Silverstone, 1998). In this decade (2020–2030), the rapid enhancement of ICT has been concentrated in several fields. ITU (2017) identified the internet of things, cloud computing, big data analytics, and artificial intelligence (AI) as the four game-changing technologies that will drive the digital transformation. Figure 1.1 shows their market size in 2015 and the projection for 2025.

Figure 1.1 Global Market for Emerging Technologies, 2015 Versus 2025



AI = artificial intelligence, IoT = internet of things.

Source: Bauer (2017).

Digital transformation policy analyses cannot be separated from technological adoption factors. When a technology is introduced to the market, users exhibit a subjective value of how they perceive the technology and how they will use it. The ideal condition is for the technology to increase the welfare and economic power of its users. Thus, at the centre of the digital transformation, policymakers should be able to understand messages from the market/society during the diffusion of technologies and synchronise them with the relevant strategic policies.

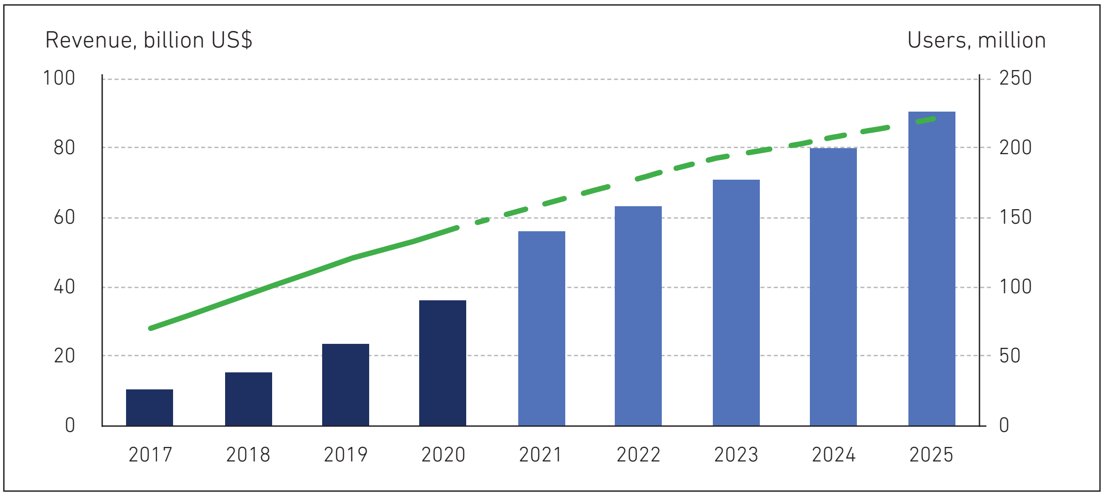
In a similar way, policy design for digital transformation cannot be separated from market and technological adoption factors. According to Flacher and Jennequin (2008), regulatory policies are made to develop competition, with the purpose of ultimately increasing efficiency and social welfare. This is one of the primary functions of policy – to structure the implementation of digital technology in the market so that society will obtain the greatest benefit. However, different countries deploy different policy approaches aimed at pursuing social welfare in their respective societies.

Hence, the relationship between technology and the market, where the market or society, as technology users, must be understood as a whole and comprehensively. This relationship must be combined with an understanding of the relevant technological regime, defined as the attributes of a technological environment where firms' innovation activities take place. Such a holistic understanding allows policymakers to extract lessons learnt so that they can design the optimal strategies to support the desired digital transformation. Asia could benefit more than any other region by turning the potential induced by digital technology into reality. The next Asian miracle of growth could be born through the region's digital transformation in the new era, whose new ideas, new technologies, new mindset, new tools, and new business are changing the way people live, work, and study. The ASEAN Economic Community Blueprint 2025 (AEC 2025) highlights the importance of incorporating economic digitalisation in regional development. Considering the rapid growth of the digital economy and the region's potential in this area, the concept of digital integration has been part of the content of the AEC 2025 and has shown its importance in contributing to the success of the Consolidated Strategic Action Plan. Moreover, digital transformation will help the region achieve the five objectives defined in the ASEAN Social-Cultural Community Blueprint 2025 (ASCC 2025).

Indonesia is the largest Association of Southeast Asian Nations (ASEAN) economy in terms of gross domestic product (GDP) and population. It also has a fast-growing online market. By the end of 2019, the rate of 3G/4G coverage reached 93%, and the country had about 130 million internet users (Statistics Indonesia, 2022). Nearly 90%

of these users used e-commerce (Statista, 2022). From 2017 to 2019, the number of internet and e-commerce users increased by 50% and 70%, respectively. During this period, e-commerce revenue rose from $9 billion to more than $20 billion annually. The Indonesian e-commerce market is projected to keep growing at an average rate of 25% per year from 2021 to 2025 and achieve as much as $90 billion in 2025 (Figure 1.2).

Figure 1.2 Indonesian E-commerce Market



Source: Authors. Raw data from Statista (2022).

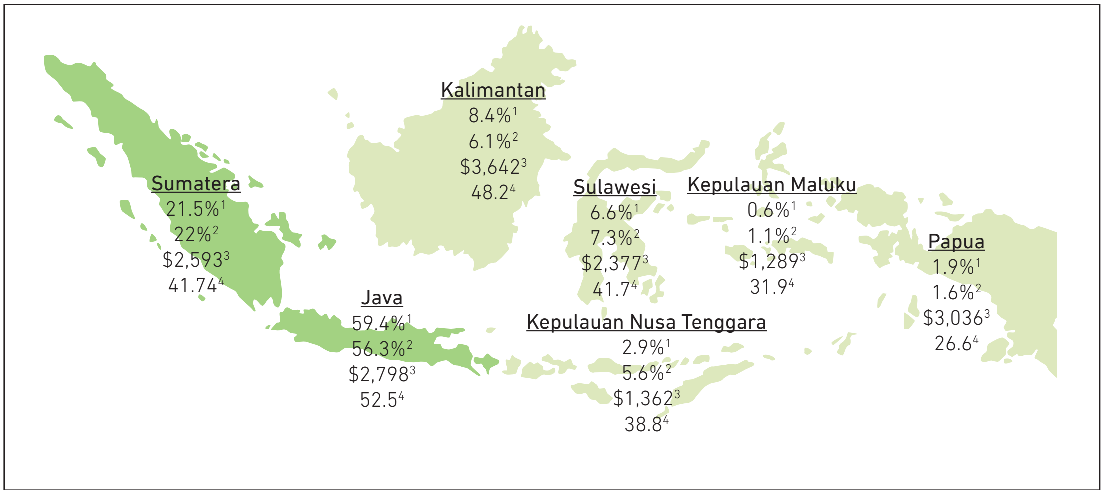
Indonesia will benefit from its relatively young population and high literacy rate. The 2020 census showed that the country's median age was 31.1 years, with 71% of the population aged 15–64.[1] Thanks to the compulsory education for children through age 18, 93% of Indonesians aged 15 and above can read and write in Bahasa Indonesian (World Bank, 2022). With digitalisation facilitating self-learning and online training, a large pool of educated youth will be an asset for economic development in Indonesia.

Despite its progress and growth potential, Indonesia needs to accelerate the pace of its digital transformation. It faces various challenges in this respect. Improving connectivity and minimising the digital divide are top priorities. The economic geography of Indonesia is characterised by its archipelagic profile. The interlinkages amongst different islands or regions are rather weak, and the cost of domestic logistics remains high. This has fragmentised national economic activities and created barriers for economic growth, making unevenness the key feature of the Indonesian economy as well as many other aspects of development (Kimura and Chen, 2018).

[1] Life expectancy is 73 years.

Indonesia's Gini ratio was 0.38 in 2019 (World Bank, 2022). The GDP per capita of the Special Capital City District of Jakarta is more than 10 times higher than that of East Nusa Tenggara, one of the least developed regions of the country. Some 27 out of the 34 provinces had GDP per capita higher than the national average (Statistics Indonesia, 2022). Nearly three-fifths of the population live in Java. The island contributes 60% of Indonesia's GDP and has the highest internet penetration, at 52.5%. In comparison, less than one-third of the population living in Papua and Kepulauan Maluku were internet users at the end of 2019. Mobile subscribers reached 331 million in September 2020, surpassing the country's population of 270 million (Figure 1.3).

Figure 1.3 Economy Geography of Indonesia



GDP = gross domestic product, US = United States.

Notes:

1. Share of national GDP of 2019
2. Share of national population of 2019
3. Average GDP per capita of 2019 (US dollars in constant 2010 prices)
4. Internet penetration of 2019

Source: Authors. Raw data from Statistics Indonesia (2022).

The table shows internet and cellular penetration at the provincial level. Two types of gaps are worth noting. First, wide gaps in cellular penetration persist between urban and rural areas – 70% of the urban population has owned at least one mobile phone, while only half of the population use mobile phones in rural areas. Second, the number of internet users is much lower than that of cellular users, meaning that a significant number of Indonesians still use mobile phones with 2G technology – without the capacity to access the internet.

Table 1.1 Internet Penetration and Cellular Penetration in Indonesia: Provincial Data

Island Province		Internet users (% of population)	Cellular/mobile users (% of population)		
			Overall	Urban	Rural
Sumatera		41.7	62.5	71.2	56.0
	Aceh	35.6	57.8	69.0	52.3
	Sumatera Utara	41.4	60.7	67.6	52.3
	Sumatera Barat	41.2	62.6	71.3	54.9
	Riau	45.0	67.3	74.9	62.2
	Jambi	42.7	64.8	75.3	59.7
	Sumatera Selatan	38.1	60.7	71.3	54.4
	Bengkulu	40.7	61.2	74.9	54.4
	Lampung	40.2	61.5	71.3	57.2
	Kep. Bangka Belitung	45.9	67.8	72.9	61.4
	Kep. Riau	65.0	76.4	77.7	64.9
Java		52.5	64.9	69.1	52.0
	DKI Jakarta	73.5	78.4	78.4	-
	Jawa Barat	53.9	66.2	69.1	56.8
	Jawa Tengah	47.7	61.7	66.0	57.1
	Di Yogyakarta	61.7	67.7	71.7	56.8
	Jawa Timur	47.1	62.2	68.5	54.9
	Banten	56.3	65.2	70.5	52.0
Kepulauan Nusa Tenggara		38.8	56.3	67.7	48.9
	Bali	54.1	69.6	74.4	59.1
	Nusa Tenggara Barat	39.2	57.1	62.9	51.6
	Nusa Tenggara Timur	26.3	45.0	66.9	38.1
Kalimantan		48.2	67.9	77.5	60.7
	Kalimantan Barat	38.4	58.6	74.3	50.1
	Kalimantan Tengah	46.7	70.3	79.8	63.8
	Kalimantan Selatan	50.4	69.0	78.2	60.7
	Kalimantan Timur	59.1	76.9	79.3	71.9
	Kalimantan Utara	54.3	74.3	79.3	66.5

Island Province	Internet users (% of population)	Cellular/mobile users (% of population)		
		Overall	Urban	Rural
Sulawesi	41.7	62.8	72.2	56.5
Sulawesi Utara	46.7	67.9	74.7	60.4
Sulawesi Tengah	35.5	57.7	71.3	51.8
Sulawesi Selatan	43.9	65.1	73.8	58.4
Sulawesi Tenggara	41.9	62.7	72.5	56.3
Gorontalo	41.8	60.4	68.2	54.6
Sulawesi Barat	31.3	52.2	62.0	49.1
Kepulauan Maluku	31.9	55.6	71.5	46.2
Maluku	33.9	57.0	69.9	46.7
Maluku Utara	29.1	53.7	73.8	45.5
Papua	26.6	44.8	75.5	31.9
Papua Barat	43.5	66.5	76.8	59.0
Papua	21.7	38.5	75.2	24.0

Source: Authors. Raw data from Statistics Indonesia (2022).

Digitalisation is not a development status, but a continuous process of transformation. At each milestone, it is necessary to assess the achievements so far and the plan for the remainder of the journey. Indonesia has set up an important framework for its agenda for the Acceleration of National Digital Transformation. The Making Indonesia 4.0 Roadmap, launched in April 2018, is designed to respond to the challenges of economic diversification and address trade imbalances. This initiative is Indonesia's effort to reduce dependence on the extractive industries while increasing high-value exports, which will enable the country to compete economically with the newly developed economies in Asia.

This book provides insights on Indonesia's digital transformation. Its analysis covers three aspects – technology, the market, and policy.[2] It shows how the new international division of labour could expand the policy space – i.e. with digitalisation, policymakers will have more options to customise development strategies for different regions within the country, depending on their conditions and constraints. This volume investigates the technology–market–policy dynamics at the micro level and sheds light on how digitalisation, competition, innovation, and human development can interact to promote development.

[2] Kimura and Chen (2018) revealed some of their interlinkages at the macro level.

The next chapter surveys the actions undertaken by the Government of Indonesia to accelerate digital transformation. It discusses how digitalisation will play a notable role in improving Indonesia's global competitiveness. Chapter 3 examines the underlying policy motivations and constraints from the perspective of technology progress and adoption. Chapter 4 explores the possible economic consequence of digital transformation. Chapter 5 summarises the findings and proposes policy recommendation on how Indonesia can unlock the potential of using new technology and better harness opportunities brought about by digital transformation.

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CHAPTER 2

POLICY DEVELOPMENT TO ACCELERATE DIGITAL TRANSFORMATION

Kalamullah Ramli

1. INDONESIA'S DIGITAL TRANSFORMATION AGENDA

Governments need to create a holistic view of digital transformation, including not only the public sector but also the key business sector. The country's digital transformation strategy equips the government with a vision of how to sustainably lead digital transformation and create impacts for all of society.

Indonesia has set up an important framework for its agenda for the Acceleration of National Digital Transformation. The government, through the Ministry of Communications and Informatics, is currently working on accelerating national digital transformation by outlining five priorities (Republic of Indonesia, Cabinet Secretariat, 2020). The agenda is depicted in Figure 2.1 (in Indonesian language).

The first priority is to accelerate the development of digital infrastructure, including adequate internet access for 12,548 villages/sub-districts and 150,000 public service points (including health services). The second is to perform radio spectrum re-farming for network efficiency and the development of 5G technology. Also is the start of work for the development of the National Data Center (PDN), which is necessary to implement the One Data Indonesia strategy. The third is to initiate comprehensive and sustainable human resource development in the digital sector, starting with talent and literacy in that area and progressing to leadership in the digital era . The fourth is to prepare a digital transformation roadmap in strategic sectors, such as the government sector, public services, social welfare support, education, health, trade, industry, and broadcasting. Fifth is the completion of primary legislation to support the digital ecosystem. These, in particular, are the Bill on Personal Data Protection (RUU PDP) and the Bill on Job Creation in the telecommunications/broadcasting sector, which are expected to speed up the digitalisation of national television.

Figure 2.1 Indonesia's Digital Transformation Acceleration Agenda

Source: Republic of Indonesia, Cabinet Secretariat (2020).

Related to the first agenda, the government should drive the implementation of 5G and Industry 4.0 infrastructure, which will enable digital transformation. Expected outcomes include new job creation from new industries as well as improved living standards and lifelong learning opportunities to build the knowledge and skills required for the new economy.

2. THE MAKING INDONESIA 4.0 PROGRAMME

The Making Indonesia 4.0 programme (Kementerian Perindustrian, 2018b), launched in April 2018, is designed to respond to the challenges of economic diversification and address trade imbalances. The initiative is Indonesia's effort to reduce reliance on extractive industries whilst growing high-value exports, which will enable the country to economically compete with the established 'Asian Tigers', such as Japan, the Republic of Korea, and Taiwan.

Through this programme, the Indonesian government also wants to raise Indonesia's competitiveness in the Industry 4.0 era by utilising the power of disruptive technologies to considerably boost national manufacturing performance and productivity. The programme is further expected to accelerate Indonesia's transition from a resource-based economy to a knowledge-based and innovation-driven economy.

2.1. INDONESIA IS COMMITTED TO BUILDING A STRONG MANUFACTURING INDUSTRY

The Making Indonesia 4.0 initiative offers great potential to significantly improve labour productivity and, in turn, enhance global competitiveness and increase the export market share. An increase in export volume will potentially create more jobs and, thus, strengthen national purchasing power.

2.1.1. To be in the top 10 of world economic powers based on gross domestic product

Indonesia plans to become one of the top 10 largest economic powers in the world based on the gross domestic product (GDP) by 2030. Indonesia's GDP growth is estimated to be 5.1% in 2022, even though the country's economy is still recovering. This is partly due to strong domestic consumption and investment. Going forward, Indonesia should explore its potential for net exports as an economic driver by improving productivity and implementing innovation in the industry.

2.1.2. Improving the productivity-to-cost ratio

Indonesia should focus on doubling output from the current basic labour cost. The resulting productivity and profitability would improve competitiveness in the global market. This conducive situation will encourage industry players to reinvest the profits they earn in productive assets, thus creating a useful economic cycle.

2.1.3. Boosting net exports to 10% of GDP

Indonesia was once one of the countries with the highest net exports in the Association of Southeast Asian Nations (ASEAN). However, this advantage seems to have decreased over the last period, with a decrease in the number of net exports as a percentage of GDP from 10% in 2000 to 1% in 2016. With the Making Indonesia 4.0 initiative, Indonesia wants to increase its share of the global export market, create more jobs, and reclaim the triumph of net exports by achieving net exports of 10% of GDP by 2030.

2.1.4. Budgeting 2% of GDP for research and development

4IR leverages advanced technologies, such as artificial intelligence (AI), the Internet of Things (IoT), advanced robotics, and 3D printing. Research and development, as well as design and innovation activities, are needed to improve the ability of the nation in mastering these technologies. Through Making Indonesia 4.0, Indonesia is committed to allocating 2% of GDP to encourage future technology adoption and development.

2.2. DEVELOPING FIVE MANUFACTURING SECTORS TO COMPETE IN THE REGIONAL MARKET

To increase exports and competitiveness on a global scale, the government plans to modernise five important industries under the Making Indonesia 4.0 initiative: electronics, food and beverage, textiles, automotive, and chemicals. These sectors were selected after an evaluation of the implementation feasibility criteria, which include the economic impact, size of GDP, trade volume, the potential impact on other industries, the size of the investment, and speed of market penetration.

The five industrial sectors contribute 60% to GDP and 65% to total exports (Kementerian Perindustrian, 2018a). Moreover, 60% of the industrial workforce is absorbed by these five sectors.

All of these industries benefit from the economies of scale of the domestic market, and hence, they can start their Industry 4.0 journey with a relatively solid foundation supported by established supply chains and solid trade. To review progress and address implementation challenges, the strategies for the focus of each of these sectors will be evaluated every 3–4 years.

2.2.1. Food and beverages: Building the food and beverage industrial powerhouse in ASEAN

In 2016, the food and beverage (F&B) sector contributed 29% of Indonesia's manufacturing GDP, 24% of manufacturing exports, and 33% of the manufacturing sector workforce (Hardjoeno, 2021). Compared to other countries, Indonesia's food and beverage sector is believed to have great growth potential because it is supported by abundant agricultural resources and large domestic demand.

Strategies for food and beverage 4.0 include (Kementerian Perindustrian, 2018b):

a. Encouraging productivity in the upstream sector – agriculture, livestock, and fisheries – by implementing and investing in advanced technologies, such as automated monitoring systems and autopilot drones.
b. As more than 80% of the workforce in this industry works in micro, small and medium-sized enterprises (MSMEs), including small-scale farmers and producers, Indonesia will assist MSMEs along the value chain to adopt technologies that can increase their production yields and market share.
c. Committed to investing in packaged food products to anticipate increased domestic demand in the near future.
d. Increasing exports by optimising access to agricultural resources and leveraging huge domestic economies of scale.

2.2.2. Textiles and clothing: Towards becoming a leading functional clothing manufacturer

In 2016, the textiles and clothing sector accounted for 7% of manufacturing GDP, 15% of manufacturing exports, and 20% of the manufacturing workforce (Kementerian Perindustrian, 2018b). Historically, this sector has been the second-largest contributor to manufacturing exports in Indonesia. The adoption of 4IR in this sector will enable Indonesia to maintain and increase its competitiveness in the global market share.

The textiles and clothing strategy 4.0 includes (Kementerian Perindustrian, 2018):

a. Improving capabilities in the upstream sector, focusing on the production of high-quality chemical fibres and clothing materials at lower costs.
b. Increasing manufacturing and labour productivity through the implementation of advanced technology, the optimisation of factory locations, and the upgrading of skills.
c. Along with economic growth and the shift in demand, from basic clothing to functional clothing, such as sportswear and surgical clothing, Indonesia must be able to build functional clothing production capabilities.
d. Increasing economies of scale to meet the growing demand for functional clothing, both in the domestic and export markets.

2.2.3. Automotive: Becoming a leading player in internal combustion engine vehicle and electric vehicle exports

Indonesia wants to become the largest auto producer in the ASEAN region, helped by a sizable domestic market and significant investment from top automakers. Currently the second-largest exporter of automobiles in the area, Indonesia still imports raw materials for manufacturing automobiles, including metals, chemicals, and other crucial electrical components.

As the penetration and demand for global electric vehicles (EV) are expected to increase sharply in the near future, Indonesia is focusing on supporting EV development.

The automotive 4.0 strategy includes (Kementerian Perindustrian, 2018b):

a. Increasing local production, in terms of volume.
b. Improving the production efficiency of raw materials and critical components by adopting new technologies and developing infrastructure, such as creating integrated industrial zones and more effective logistics systems.
c. Cooperate with global original equipment manufacturers (OEMs) to increase exports, with a focus on multi-purpose vehicles, low-cost vehicles that are environmentally friendly, and sport utility vehicles.
d. Building an ecosystem for the EV industry, starting with electric motorcycle manufacturing capabilities, then developing electric car capabilities based on the inevitable future adoption of EVs.

2.2.4. Chemical: Becoming a leading player in the biochemical industry

The development of the chemical industry is crucial since a variety of manufacturing industries, including the pharmaceutical, electronics, and automobile industries, heavily rely on its output. For the manufacturing sector to compete worldwide, the chemical industrial sector must be strengthened.

Indonesia is now importing basic chemicals but intends to develop its capacity to produce and export special chemicals. Indonesia can create a competitive advantage in the production of biochemical products by using its enormous agricultural resources as capital.

The chemical industry strategy 4.0 includes (Kementerian Perindustrian, 2018b):

a. Increasing the domestic petrochemical supply capacity to reduce dependence on imports.

b. Developing a more efficient and competitive chemical industry through the utilisation of oil and gas resources, as well as optimising the geographical location of industrial districts by constructing chemical manufacturing facilities near natural gas extraction sites.
c. Implementing Industry 4.0 technology and accelerating research and development activities to boost productivity, as well as developing next-generation chemical production capabilities, in particular, the production of biofuels and bioplastics

2.2.5. Electronics: Developing the capabilities of domestic industry players

The electronics market in Indonesia is still growing and is supported by both local manufactures from international suppliers and imported parts. Local production is still limited to simple assembly with little involvement in higher-level value-added processes.

The electronic strategy 4.0 is (Kementerian Perindustrian, 2018b):
a. Attract leading global players to invest through attractive incentive packages.
b. Improving capabilities in producing value-added electronic components.
c. Developing the capacity of the domestic workforce through intensive training.
d. Developing competent domestic leading industrial players to encourage further innovation and accelerate technology transfer.

2.3. PROMOTING 10 NATIONAL PRIORITIES

Indonesia's industry is frequently hampered by cross-sectoral issues. As a result, Making Indonesia 4.0 includes 10 cross-sectoral national projects to hasten the growth of Indonesia's manufacturing sector. Five of the initiatives (in bold) are the most relevant ones in this study. The 10 initiatives are as follows:
i. Improving the flow of goods and materials
ii. Redesign of industrial zones
iii. Accommodate sustainability standards
iv. Empowering MSMEs
v. Building a national digital infrastructure
vi. Attract foreign investment
vii. Improving the quality of human resources
viii. Development of an innovation ecosystem
ix. Incentives for technology investment
x. Harmonisation of rules and policies

To instigate the Roadmap for Making Indonesia 4.0, Indonesia is committed to speeding up the development of digital infrastructure, including high-speed internet and high-throughput satellites. The government, through public and private partnership schemes, also plans to invest in digital technologies such as cloud computing, data centres, and security management. Indonesia, further, intends to align national digital standards to global norms and encourages collaboration between industry players to accelerate digital transformation

Human resources are an essential factor for achieving the successful implementation of the Making Indonesia 4.0 programme. Indonesia plans to update the educational curriculum to place greater emphasis on STEAM subjects (science, technology, engineering, the arts, and mathematics) and to better connect it with business demands. Further, Indonesia will work closely with industry players to improve the quality of vocational schools and the transfer of skills and knowledge and develop labour mobility programmes.

The innovation ecosystem is an important requirement for the success of Making Indonesia 4.0. A blueprint for a national innovation centre is to be developed; innovation centre piloting is to be prepared; and relevant policy and regulations, including the protection of intellectual property rights and fiscal incentives to accelerate cross-sector collaboration between private businesses and universities, are to be harmonised and optimised.

Incentives encourage innovation and technology adoption. In order to encourage enterprises to use Industry 4.0 technology, the Indonesian government has launched a scheme that includes subsidies, corporate tax breaks, and import tax exemptions. To give further assistance for investment and innovation efforts in the sector of high technology, Indonesia has also established a governmental investment fund.

Making Indonesia 4.0 is expected to promote real GDP growth of 1%–2% annually, increasing GDP growth from the baseline of 5% to 6%–7% in the period from 2018 to 2030, with the manufacturing sector accounting for 21%–26% of GDP in 2030 (Kementerian Perindustrian, 2018b). This GDP growth is to be driven by a significant increase in net exports, where Indonesia is expected to reach a net exports-to-GDP ratio of 5%–10% by 2030. Making Indonesia 4.0 also asserts that by 2030, higher export demand will result in the creation of 7 million–19 million jobs, both in the manufacturing and non-manufacturing sectors

With the above potential benefits, Indonesia is committed to implementing Making Indonesia 4.0 and making it a national agenda. In the first half of 2018, Indonesia began to compile a task force for five focus sectors (food and beverages, textiles and clothing, automotive, chemical, and electronics) and 10 cross-sector priorities. Each task force has clear duties and responsibilities. In the second half of 2018, this task force prepared the main plan and details of an action plan and began to carry out the initiatives and coordinate to ensure that the implementation of Making Indonesia 4.0 runs smoothly.

3. BUILDING NATIONAL DIGITAL INFRASTRUCTURE

Indonesia lacks a core digital infrastructure for the implementation of Making Indonesia 4.0. Amongst the core infrastructure required are fibre optic connections, the implementation of 5G technology, and data centre and cloud infrastructure.

Industry 4.0 is closely related to the provision of information and communication technology infrastructure, such as IoT, big data, cloud computing, AI, mobility, virtual and augmented reality, and sensor and automation systems. It will be a big challenge for Indonesia to adjust to the dynamics of Industry 4.0.

The success of Industry 4.0 – including the Making Indonesia 4.0 – will greatly depend on the success of the digital transformation process. To realise this, the recommended policies are proposed as follows:

1. The establishment of digital transformation enablement, especially the deployment of infrastructure and the utilisation of IoT, 5G, cloud computing, and big data technology must be accelerated and be on target.
   It should be accelerated in the sense that it is not left to the market mechanism, nor the supply-demand relationship, but there should be policies in the form of encouragement and convenience for the industry to deploy the infrastructure.
   Meanwhile, it should be on target in the sense that the deployment is prioritised in industrial areas or industrial centres – in particular, industrial areas where factories are included in the five priority sectors of Making Indonesia 4.0. More specifically, the deployment acceleration should be carried out at factories that already have the commitment and readiness to implement the Making Indonesia 4.0 programme.
2. Commitment to fulfilling international standards for digital infrastructure in industrial estates. For example, the quality of fixed fibre optic networks, 5G wireless networks, the availability of IoT services for smart factories, the availability of big data services, and cloud computing applications for business intelligence.

Furthermore, policy for digital infrastructure development in five priority industry sectors needs to be supported by the following propositions:

Proposition 1. The development of digital infrastructure that is needed is not the equal distribution of infrastructure and networks in all areas but the availability of adequate infrastructure and networks at factory points that are more ready to run Industry 4.0.

Proposition 2. The deployment of digital infrastructure and networks with a private network or industrial campus network approach to support smart factories is more feasible than deploying public networks to industrial areas in general with a smart city orientation.
Proposition 3. Based on the characteristics of IoT applications and services, the deployment of indoor digital infrastructure and networks to support smart factories or smart manufacturing needs to be prioritised over outdoor services
Proposition 4. The characteristics and types of digital infrastructure and networks required for each industry sector and smart factory will depend on the respective and applied 5G use cases.
Proposition 5. The selection of a 5G use case that is suitable for each sector and factory must refer to the readiness and peculiarities of each sector or factory to get optimal benefits from the implementation of Industry 4.0.

3.1. FIVE 5G IMPLEMENTATION READINESS ASPECTS IN INDONESIA

Until the end of 2020, many countries carried out 5G trials, including Indonesia. Some have launched 5G pilot projects. Pilot projects are very important for preparing for the arrival of 5G.

Countries that have traditionally been pioneers in research, development, and technology adoption are likely to continue to lead the '5G race', whilst countries that are traditionally technology buyers are also hoping for a share of the 5G economic pie. Overall, each country's 5G readiness depends on economic, operational, and social factors.

The readiness of a country to adopt technology can be viewed from five aspects. These aspects are infrastructure readiness, technological readiness, human capital readiness, regulatory and policy readiness, and market readiness. This ecosystem is illustrated in Figure 2.2.

In Indonesia, the deployment of the 4G network came into effect at the end of 2014. According to a report by Kementerian Komunikasi dan Informatika (2018), up to Q4 2018, 4G signal coverage had covered 95.84% of residential areas throughout Indonesia. By area, this was still slightly below 2G coverage, which reaches 98.06% of residential areas. However, 5G is supposed to be the key driver for a future manufacturing ecosystem called Industry 4.0 and, hence, Indonesia is expected to deploy 5G technology services selectively and carefully in order to avoid further deficits in the telecommunication operator business.

Figure 2.2 **5G Adoption Readiness in Indonesia**

Source: Author.

The migration of technology from 4G to 5G requires users to change their end terminals, known as customer premises equipment (CPE). The CPE must be universal to all services and be able to operate on a variety of wireless network platforms. It must also address the issue of device utilisation, in addition to the issue of selling price and performance of the battery.

The next challenge is how cellular operators can educate the market to increase the demand for 5G services, especially enhanced mobile broadband (eMBB), which targets general users. Likewise is the challenge of creating a new market for 5G or IoT, namely the massive machine-to-machine communication 5G service. This kind of service is thought to have much greater economic potential than eMBB and is expected to become a new source of revenue with a new business model. Whether the timing is right to start adopting 5G depends very much on the business considerations of each operator.

In terms of the CPE industry, Indonesia in general already has a complete supply chain, starting from the design house, system integrator, and manufacturer to the brand owner (Admaja, 2015). However, the immature ecosystem is causing high dependence on global markets. This is due to the limited number of manufacturers in Indonesia.

3.2 THE OMNIBUS LAW MAKES WAY FOR 5G IMPLEMENTATION

The operation of the 5G network connection requires an adequate radio frequency spectrum as a condition for achieving the expected quality. As a limited resource, the use of the radio frequency spectrum must be optimised in order to provide maximum benefit to people.

On 5 October 2020, parliament approved Law Number 11 of 2020 concerning Job Creation, i.e. RUU Cipta Kerja, commonly known as the 'Omnibus Law', which introduces key amendments to several sectors. The Omnibus Law is a legal breakthrough that amends more than 75 laws. As a follow-up, the central government is required to issue more than 30 government regulations and other implementing regulations.

The Omnibus Law covers the amendments to Law No. 36 of 1999 on Telecommunications ('Telecommunications Law') and Law No. 32 of 2002 on Broadcasting ('Broadcasting Law'), which impact the telecommunications and broadcasting sectors in Indonesia. Amongst others, the law regulates optimising the use of the radio frequency spectrum, including the use of 5G networks in Indonesia. This provision is contained in Article 71 number 5 of the Omnibus Law, which permits the shared use of a radio spectrum.

The sharing and transfer of the spectrum, infrastructure sharing, and the migration to digital technology broadcasting, also known as the analogue switch-off, are three of the important takeaways from the Omnibus Law for the telecommunications and broadcasting industries in Indonesia (Pardede et al., 2020). Telecom providers are permitted to exchange and transfer the spectrum under the Omnibus Law so long as they have first received authorisation from the government. Holders of frequency spectrum licences are allowed to work together in spectrum sharing to deploy innovative technologies. The owner of a frequency spectrum licence may also grant another telecommunications operator permission to use the spectrum.

The licence for spectrum sharing and transfer is required for legal certainty for the implementation of mergers and acquisitions (M&A) between telecommunications operatorsonce the M&A implementation is completed. Further, the government also needs to replace Government Regulation Number 52 of the year 2000 concerning Telecommunications Operations and Government Regulation Number 53 of the year 2000 concerning Use of Radio Frequency Spectrum and Satellite Orbit to eliminate rules that prohibit the transfer and sharing of the spectrum between telecommunications operators.

For telecom carriers, building passive infrastructure like towers and ducting has grown to be a considerable cost. The Omnibus Law mandates telecommunications companies to share passive infrastructure. The goal is to use the passive infrastructure as efficiently as possible. Small and medium-sized telecom providers might expect convenience and capital efficiency from this business strategy.

The Omnibus Law also specifies that local and national governments may collaborate on the development of passive infrastructure for shared usage by telecom carriers. It is also possible to share active infrastructure but only with mutual consent between the parties.

The Omnibus Law stipulates the migration of terrestrial television broadcasting from analogue technology to digital technology – known as the analogue switch-off – within two years of its enactment. This migration would result in spectrum efficiency. Part of the spectrum allocation currently used for analogue technology can be reallocated to other services, such as the future technology of 5G networks and high-speed wireless communications.

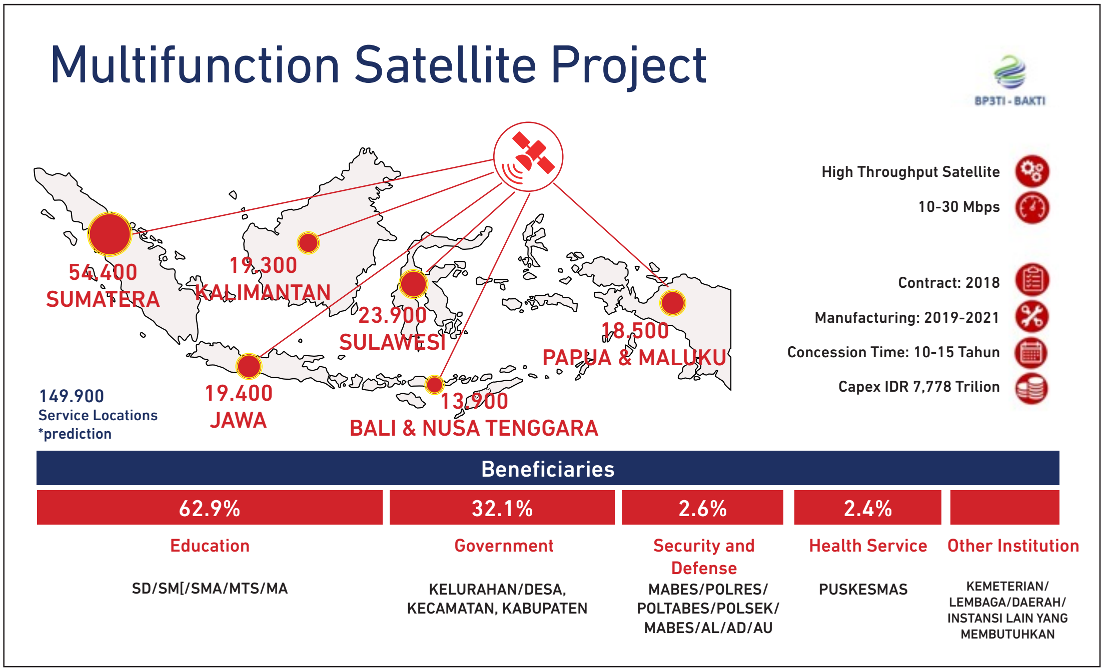
The provisions described above are amongst the government's efforts to prepare for the implementation of digital transformation in Indonesia, including the deployment of the 5G network.

3.3 SATRIA-1: HIGH THROUGHPUT SATELLITE FOR REMOTE PUBLIC SERVICE POINTS

The government has initiated the procurement of the SATRIA-1 multifunction satellite, which was carried out through a public-private partnership scheme. In March 2021, it had entered the stage of fulfilling project financing. The collaboration project with PT Satelit Nusantara Tiga uses the high throughput satellite technology produced by Thales Alenia Space from France, with a rocket launcher produced by Space-X from the United States, namely the Falcon 9-5500.

150,000 people in Indonesia will have access to the internet through the SATRIA-1 satellite from a total of 501,112 public service points that do not already have it. 3,700 health facilities, 93,900 schools and Islamic boarding schools, 47,900 village offices, and 4,500 other public service points make up the 150 000 public service points. An infographic of this programme is shown in Figure 2.3.

Figure 2.3 SATRIA-1 Project



Source: BAKTI (2020).

The total satellite transmission capacity is 150 gigabits per second. Each service point will get a capacity with a speed of 1 megabit per second. According to the agreed schedule, the SATRIA-1 satellite is expected to operate in Q3 2023.

4. A 5G USE CASE AND ITS RELEVANCE TO INDUSTRY 4.0

Indonesia is a technology follower in telecommunications. Whilst operators are still struggling to think of the most feasible business model for their business when deploying 4G, starting in 2014, 5G technology has begun to be adopted in the Republic of Korea and Japan since 2020.

With the massive growth in cellular data traffic, telecommunications operators will eventually run out of their bandwidth capacity, especially in urban areas. In addition to the need for an adequate spectrum, their networks will need to be upgraded using new technology — such as a new radio standard with higher spectrum efficiency, or massive multiple-input multiple-output (MIMO) antennas that allow beam formation. These advantages are offered by 5G technology. To accommodate spectrum needs, frequencies occupied by older standards, such as 3G and 2G, will be re-farmed for 5G to meet traffic demands, whilst 4G/LTE-A will remain in the foreseeable future as a solid data layer with national coverage.

Many industry experts understand and think that new use cases will be the driving force behind the implementation of 5G technology. The most talked-about use cases right now are immersive media made feasible by augmented reality and mixed reality applications, autonomous driving made possible by real-time information, manufacturing moving towards Industry 4.0, and 5G fixed-wireless connectivity that is expanded to more houses.

Telecommunications operators should understand the use cases if they are to effectively invest in 5G. The considerations are twofold (Kearney, 2018). First, with their limited capital expense capabilities, they need to make the right trade-offs in launching the network in terms of coverage, capacity, and capability. Second, as more than just connectivity providers, they must develop the competencies needed to become better partners for customers and to turn the most promising use cases into reality.

Aside from 5G fixed wireless access, which can be implemented as soon as the frequency is available, on-site solutions for industrial campuses as well as the use of public spaces, such as stadiums for live event experiences and mobile mixed reality games, are the most likely use cases to be realised along with today's 4G. With Industry 4.0, factories will become increasingly automated and flexible, requiring a substantial and intensive flow of information on the factory floor.

Adding 5G coverage to industrial campus sites could enable the transformation to Factory 4.0, given the technology's throughput, latency, reliability, and mobility support capabilities. The potentially most relevant use cases for 5G here are remotely monitoring and controlling mobile and stationary equipment, product tracking, machine-to-machine closed-loop communication, and the use of augmented reality/mixed reality to support industrial design processes, as well as other manufacturing activities, such as maintenance and repairs.

Given the huge investment required in deploying 5G services and many options for first-place investment that need to be considered, mobile operators must engage deeply with their customer base – in particular, on the industry or factory side – and collectively assess which use cases should be enabled, and by when. In order to optimise Factory 4.0, it is necessary to break down the major issues into specific use cases, analyse the requirements for effective digital infrastructure, assess the maturity of other necessary technologies, and establish a shared road map.

This way, telecommunications operators can be sure that their investment will pay off – either through connectivity fees or other business models. The same is true for industry players as they need to accept that many capacities, such as frequency, construction, and investment funds, are limited. They need to be highly selective about what to do first.

To illustrate the requirements along the supply chain and manufacturing network of the future generation of linked factories in manufacturing, five sets of use cases have been presented (5G-PPP, 2015). The factories of the future will not exist in isolation as closed systems but rather as a crucial component of a bigger value chain and ecosystem.

Table 2.1 depicts five use case families, each illustrated for a specific targeted application and representative scenario whilst highlighting the expected impacts on manufacturing as well.

Table 2.1 **Factory Use Cases and the Expected Impacts (5GPP, 2015)**

	APPLICATION	Representative SCENARIO	Expected IMPACT
Use Case Family 1	Time-critical process optimisation inside factory	Real-time closed loop communication between machines to increase efficiency and flexibility	Increased efficiency; Increased worker satisfaction; Increased safety/ security
		3D augmented reality applications for training and maintenance	
		3D video-driven interaction between collaborative robots and humans	
Use Case Family 2	Non time-critical in-factory communication	Identification/tracing of objects/goods inside the factory	Increased efficiency; Increased flexibility; Minimised stock levels; Increased eco-sustainability (e.g., emissions, noise)
		Non-real-time sensor data capturing for process optimisation	
		Data capturing for design, simulation and forecasting of new products and production processes	
Use Case Family 3	Remote control	3D augmented reality applications for training and maintenance	Increased product/ process quality
		3D video-driven interation between collaborative robots and humans	

	APPLICATION	Representative SCENARIO	Expected IMPACT
Use Case Family 4	Intra-/inter-Enterprise Communications	Identification/Tracking of goods in the end-to-end value chain	Increased efficiency (cost, time)
		Reliable and secure interconnection of premises (intra-/inter-enterprises)	
		Exchanging data for simulation/design purposes	
Bangkok	Thailand	Connecting goods during product lifetime to monitor product characteristics, sense its surrounding context, and offering new data-driven service	Increasing Sales (i.e., new products, services); Improved product/ process design

Source: 5G-PPP (2015).

5. NURTURING DIGITAL TALENTS

The modernisation of training and educational curricula is needed to produce highly competitive talent in the Industry 4.0 era. Such a programme is important for preventing job losses caused by technological advancement.

The availability of sufficient digital talent will be an important factor for economic growth in the future. A successful digital culture is reflected in the attitudes, values, and behaviours that adapt and are in line with the digital transformation agenda. It is at that time that the government should plan its vision for Indonesia 5.0 It draws inspiration from Japan's Society 5.0, one of whose objectives is to deploy Industry 4.0 uniformly throughout society so that everyone can benefit from it rather than just a select few.
Upgrading talent skills is critical for preventing the replacement of human labour with machines. Humans are still required to maximise the advantages of Industry 4.0 technology despite the efficiency it offers. Whilst robots and machines handle tedious and repetitive jobs, humans must undertake higher-value tasks. Employees must therefore urgently develop their digital abilities if they want to remain competitive and relevant in the digital era.

The Ministry of Communication and Information Technology (Kominfo) provides the Digital Talent Scholarship (DTS) programme every year. The DTS aims to address the digital competency gap in Indonesia. Scholarship recipients acquire skills through digital training, including data analytics, AI, cloud computing, and cybersecurity.

A lack of digital skills, particularly in the technology sector, is a problem in Indonesia. According to the World Bank (World Bank, 2018), between 2015 and 2030, Indonesia will have a shortage of 9 million trained and semi-skilled personnel in the digital economy. This is a reason for the digital talent scholarship programme. Around 600,000 workers are required in the digital sector annually to meet the demand for skilled workers.

To carry out the training, the ministry has teamed up with more than 90 universities and polytechnics, regional start-ups, and international technological giants like Cisco, Google, and Microsoft. The training is designed for fresh graduates, teachers, and entrepreneurs. In addition to hard skills, the participants of the scholarship also obtain soft-skill training, such as in critical thinking, creativity, and communication. The first DTS programme in 2018 was attended by 1,000 participants and this increased to 25,000 recipients in 2019. This is illustrated in Figure 2.3.

Figure 2.3 Digital Talent Scholarship

DIGITAL TALENT SCHOLARSHIP 2018	DIGITAL TALENT SCHOLARSHIP 2019
Recipients • **1.000**	Recipients • **25,000**
Locations • **5** State Universities	Locations • **30** State and Private Universities • **23** Polytechnics
Training Topics • **5** Topics	Training Topics • **22** Topics
Certified Partners • **1** Partner	Certified Partners • **4** Mitra
	Academy • **4** Academy

Source: Kementrian Komunikasi dan Informatika (2019).

The ministry has also organised online academies to train people in advanced skills, such as data analysis, digital marketing, and programming. The programme is targeted at training 50,000 participants this year. So far, 43,500 people have participated.

The Digital Talent Scholarship consists of several academy programmes. Those programmes are the Fresh Graduate Academy, Vocational School Graduate Academy, Professional Academy, Thematic Academy, Government Transformation Academy, and Digital Entrepreneurship Academy.

The Fresh Graduate Academy Digital Talent Scholarship programme is a training program designed to improve competence in the ICT field. It aims to prepare graduates who have not or are not currently working to have professional competence, in line with the development of science and technology in the era of Industrial Revolution 4.0. They are expected to be able to compete in both domestic and foreign industries.

The Vocational School Graduate Academy programme is a national competency-based training and certification programme aimed at vocational school alumni and Diploma 3 and Diploma 4 graduates who have not worked. The programme consists of technical training and certification conducted both online and offline.

The Thematic Academy programme aims to create a skilled workforce in the field of ICT so that it can increase the productivity and competitiveness of the nation in the era of Industry 4.0. In its implementation, the Ministry of Communication and Informatics involves several related parties ranging from academia and industry to the community.

The Professional Academy programme provides online training for working people to create a more adaptive and productive Indonesian workforce. It also aims to improve the competitiveness of human resources in the ICT field. Professional Academy participants learn autonomously online. Participants also set study times independently according to the specified time.

6. TECHNOLOGY POLICY RECOMMENDATIONS

Recommendations that can be proposed from the discussion of this study are as follows.

6.1. DEPLOYMENT OF 5G INFRASTRUCTURE BASED ON OPERATOR BUSINESS PLANS AND DRIVEN BY THE READINESS OF PRIORITY INDUSTRY SECTORS

Telecommunications operators started the migration from 3G to 4G technology in 2015. Operators have not yet been able to get a return on their investments for 4G technology. Therefore, the implementation of 5G is highly dependent on the readiness of telecommunications operators in terms of their business calculations.

The deployment of 5G will be driven by the needs of the industrial sector. In this case, the five priority industrial sectors have been set out by the Making Indonesia 4.0 programme. The 5G network can be used as an overlay of the 4G network, which already covers 70% of residential areas in Indonesia. This means that 5G and 4G can co-exist and complement each other. The deployment of 5G can be started in areas where the priority industrial sectors are located.

6. 2. JOINT WORKING PLAN OF THE PROPOSED PALAPA RING NEXT LEVEL PROGRAMME

Policy synergy is needed between the Ministry of Industrial Affairs, with Making Indonesia 4.0, and the Ministry of National Development Planning, or Badan Perencanaan dan Pembangunan Nasional (Bappenas) in Bahasa, which are discussing the Indonesian Broadband Plan volume 2 with the Ministry of Communication and Information. This might be termed as the Indonesia Broadband Plan Next Level.

The key to the achievement of the Indonesian Broadband Plan, Presidential Regulation number 96 of 2014, in terms of deploying wireless broadband technology, is the conformity of the government's policy plans and the business plans of the telecommunications operators, particularly cellular telecommunications operators. A similar joint working plan needs to be reapplied for the establishment of similar policies and regulations in the present and future, including the proposed Palapa Ring Next Level programme.

The Palapa Ring programme has indeed succeeded in building a fibre optic backbone that connects all districts in Indonesia. However, there is still massive work to be done. This includes the construction of telecommunications networks within the district, such as a backhaul network, that connects all sub-districts in one district.

6.3. DEVELOPMENT OF POLICY AND REGULATIONS FOR THE ACCELERATION OF THE IMPLEMENTATION OF THE IOT IN INDONESIA

There are four main issues relating to IoT adoption in Indonesia. These are spectrum readiness, device standards, the level of local components (abbreviated as TKDN in Bahasa), and data security and privacy protection.

Regulations related to the above issues need to be framed carefully, taking into account the regulations of other countries as benchmark models, and the state of implementation of global IoT which is also still developing. With the careful handling of these four issues, it is hoped that the industry in Indonesia can innovate more progressively in the foreseeable future.

In general, there is no general standard regarding the use of IoT frequencies in the world that can be used as a reference. Globally, each of the major IoT players uses different frequency standards. Thus, the standard that is widely used is the standard of the dominant device maker, and in the end, this is also followed by other manufacturers. It is considered the de-facto standard set by a particular industry that dominates the market and users.

Currently, there are no globally referenced spectrums for IoT frequencies in the world. Major IoT players use different frequency standards. Thus, de-facto, a standard set by a particular industry may dominate the market and users.

In Indonesia, IoT uses frequency options above 3.3 GHz or below 900 MHz. The frequency used within ASEAN countries can be set as a reference.

Another dilemma faced by the government is whether the frequency of IoT will be licensed or left unlicensed. Unlicensed frequencies are generally used for indoor devices. There are two parts to unlicensed frequencies, namely short-range frequencies and long-range frequencies. Short-range frequencies are commonly used for devices connected to Bluetooth, including household devices, home security, and factory automation needs.
An unlicensed frequency can be used as an enabler of innovation. However, a trial frequency can only be used for a limited time and may not be made commercial.

For device standardisation, there are two options for the government. First is adopting globally agreed standards and then conducting a post-marketing survey. The post-marketing survey is carried out to see the conformity of the certified device, which is still circulating in the market, concerning the technical requirements. The second is letting the market mechanism determine the standard of the device that best meets user expectations.

Like 4G phones in Indonesia, IoT devices should also meet the TKDN requirements. This policy is needed to prevent Indonesia from merely becoming a market for advanced technology. The government should anticipate the IoT wave by preparing regulations regarding TKDN.

IoT security standards are important to regulate. However, it is more advisable to refer to the standards developed by well-known world organisations or consortiums, such as the Global System for Mobile Communications Association, Embedded Microprocessor Benchmark Consortium, International Electrotechnical Commission, IoT Security Foundation, and the National Institute of Standards and Technology.

IoT security standard regulations are recommended to be service-layer based. Amongst the issues that need to be addressed are personal data protection, data security, data access management, data governance, interoperability, data transmission security, data encryption, network security, connectivity security, and security in IoT applications.

6.4. ANTICIPATING AI AND BIG DATA REGULATORY NEEDS

AI, big data analytics, and augmented and virtual reality are at the application layer of Industry 4.0. The regulations need to take into account relevant and important matters, including the issues described below.

A clear contract is needed on the protection of personal data and data privacy used by AI technology and its derivatives. The right for data owners that their data can only be used based on mutual consent must be guaranteed. Data owners have the right to prevent their data from being used for promotional and marketing purposes. There is also the threat of biased decisions caused by the algorithms, which might include discrimination and stereotyping.

7. CONCLUSION

Through the provision of broadband internet access, the readiness of adequate digital talent, and the application of cutting-edge technologies like fintech, blockchain, and AI, Indonesia's digital transformation targets digital accessibility, financial inclusion, productivity, and growth. The digital economy will make a substantial contribution to a sustainable and circular economy. All citizens will benefit from this in turn, regardless of their age, race, or social background.

We can create a better living environment with Industry 4.0 that includes more meaningful work, upskilled labour forces, better healthcare and education, as well as smarter and greener cities. The role of governments and all stakeholders is to introduce new technology, prepare competent human resources, and transform business processes as critical tools in Indonesia's digital economy.

Policy and regulations related to digital transformation need to be framed carefully, taking into account the regulations of other countries as benchmark models, and the state of social change which might follow these developments. More significantly, Indonesia should make sure that people come first in the process of digital transformation and that the technology serve the people rather than the other way around. A successful digital transformation could boost economic growth and business performance whilst making a significant contribution to the increasingly competitive global business ecosystem.

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CHAPTER 3

TECHNOLOGY PROGRESS AND ADOPTION

Muhammad Suryanegara

1. INDONESIAN PROFILE OF TECHNOLOGY – MOBILE NETWORK

1.1 TECHNOLOGICAL OVERVIEW OF MOBILE BROADBAND COMMUNICATIONS[1]

A continuous change in mobile technology generations – from 1G, 2G, 3G, to 4G – has created a series of progressive key technological innovations as seen in Table 3.1 (Suryanegara, 2020). Beginning with the all-analogue platform in 1G, technological change from 1G to 2G led to a fundamental innovation in the digitalisation of mobile technology, with voice as the main commodity and text messaging (SMS) as the main value-added service. The SMS innovation was globally adopted by the market, creating a prominent and unplanned success story in mobile services. In the 2G era, the global system for mobile communications (GSM) was the world's most popular standard, accounting for more than 70% of global mobile subscribers.

In the transition from 2G to 3G, technological innovation was centred on using increased bandwidth. The technical platform of Code Division Multiple Access (CDMA) as the multiple access technique enabled data communications up to 2 Megabits per second (Mbps). Meanwhile, Wideband Code Division Multiple Access (WCDMA) has been the most popular 3G standard because it supports a continuous evolution from the 2G standard of GSM. The ability of 3G to provide data communications generates pervasiveness and opens up the service innovation underlying such broadband mobile technology. The concept of service innovation started to become significant in the 3G era with the emergence of 3G-enabled multiservice creation over internet and data networks.

Innovations from 3G to 4G are focused on increased data rates by developing technical aspects of multiple-input multiple-output (MIMO) and orthogonal frequency division multiplexing access (OFDMA) as the core in baseband radio. The technical enhancement includes larger bandwidth, a multiple access mechanism, and the use of turbo coding as the channel coding scheme. It enables a peak data rate of up to 1 gigabits per second (Gbps), in which LTE Release 10 is the leading standard for such technical requirements. The introduction of 4G has intensified a massive diffusion of digital services platforms all over the world. It has opened up the early arrival of advanced services, which include smart homes, smart cities, object tracking, industry automation, and IoT.

[1] See Suryanegara (2020) for more details.

Table 3.1 Sequence of Technological Innovations from 1G to 5G

Item	1G	2G	3G	4G	5G
Main technical characteristic	Supporting cellular voice service	Supporting voice and introducing the value-added services such as SMS	Supporting multimedia communications with a data rate of 2 Mbps	Improving 3G performance by introducing a data rate of 100 Mbps for high mobility and 1 Gbps for low mobility	Supporting 3 use case scenarios: - eMBB: to perform 20 Gbps downlink - mMTC: to support 1 million devices per km^2 - uRLLC: to have 1 ms latency
Official name	N/A	N/A	IMT-2000	IMT-Advanced	IMT-2020
Key technological innovation	Analogue techniques	- TDMA - Digital modulation (e.g. GSM standard used GMSK) - Convolutional coding - Speech coding (e.g. linear predictive coding in GSM)	- Using bandwidth up 5 MHz - Multiple access technique: CDMA - Convolutional coding	- MIMO - Larger bandwidth up to 20 MHz - Adaptive modulation and coding up to 64-QAM - Multiple access technique: OFDM of subcarrier spacing up to 15 kHz - Channel coding: Turbo coding (data), convolutional coding (control plane)	57
Some leading standards	AMPS, NMT, TACS	GSM cdmaOne	W-CDMA, CDMA-2000, IP-OFDMA, TS-CDMA	LTE Advanced, IEEE 802.16m	LTE Release 15, LTE Release 16
Prominent service innovation applications	Voice	Voice, text messaging (SMS), and some other value-added services	General-purpose technology: data and internet platform to offer multiple service creation, including multimedia service, video call, internet access, etc.		
				Smart home, smart city, object tracking, industry	
					Mission-critical applications, robotic surgery, self-driving cars, industry automation, augmented reality

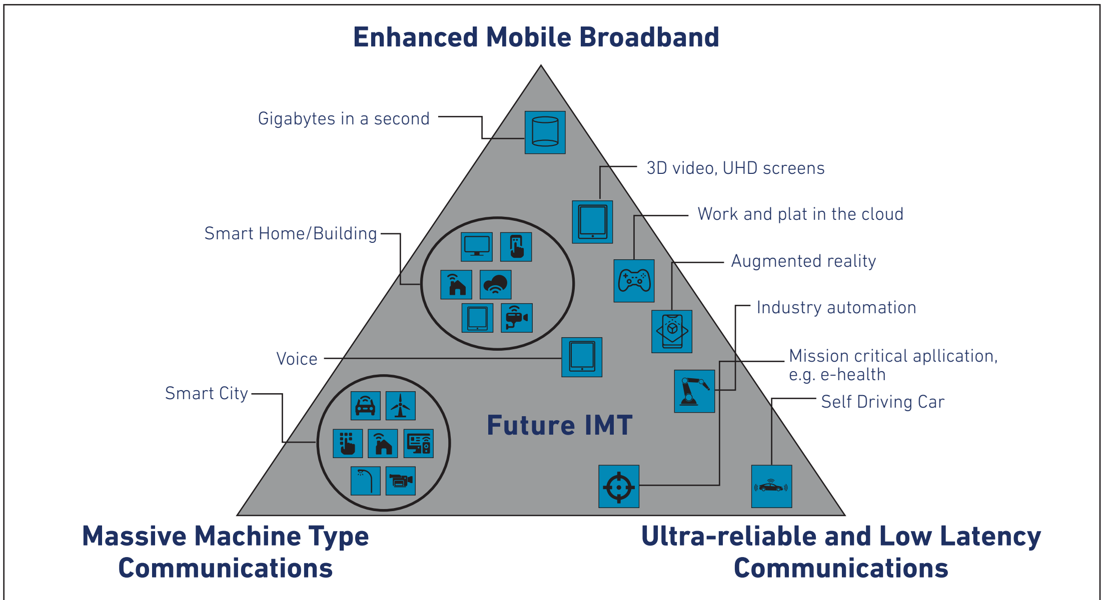
AMPS = advanced mobile phone system; AQM = adaptive modulation and coding; CDMA = code division multiple access; CP-OFDM = cyclic prefix orthogonal frequency division multiplexing; eMBB = enhanced mobile broadband; Gbps = gigabits per second; GMSK = Gaussian minimum shift keying; GSM = global system for mobile communications; IEEE = institute of electrical and electronics engineers; IMT = International Mobile Telecommunications; IP-OFDMA = internet protocol orthogonal frequency division multiple access; kHz = kilohertz; km^2 = square kilometre; LDPC = low-density parity check; LTE = Long-Term Evolution; Mbps = Megabits per second; MHz = megahertz; MIMO = multiple input multiple output; mMTC = massive machine type communications; ms = milisecond ; N/A = not applicable; NMT = Network Media Tank; OFDM = orthogonal frequency-division multiplexing; QAM = quadrature amplitude modulation; TDMA = time-division multiple access; TACS =Total Access Comunications System; TS-CDMA=time-scheduled code division multiple access= ; uRLLC = ultra-reliable low latency communications; W-CDMA = Wideband Code Division Multiple Access.

Source: Suryanegara (2020).

The research and industrial activities are conducted to develop 5G mobile technology under the umbrella of International Mobile Telecommunications (IMT)-2020. This is more than a technical enhancement; it is a technological framework with a vision to create new paradigms in connectivity, supporting a variety of digital platforms and service applications. Unlike preceding generations, 5G is no longer just about increasing speed, but also about how to facilitate massive IoT and applications at extreme low latency. It will enable more advanced services, such as mission-critical applications, robotic surgery, self-driving cars, industry automation, and augmented reality.

There are three use cases for 5G: (i) enhanced mobile broadband (eMBB), with a technical target to perform 20 Gbps downlinks; (ii) massive machine type communications (mMTC), with a technical requirement to support 1 million devices per square kilometre; and (iii) ultra-reliable low latency communications (uRLLC), with a target of supporting 1 ms user plane latency (Figure 3.1).

Figure 3.1 Use Cases of 5G Mobile Technology



Source: ITU (2015).

1.2. INDONESIAN TECHNOLOGICAL ECOSYSTEM

The mobile technology ecosystem has been structured by the service operators deploying the network infrastructure; technological suppliers (vendors) providing the technical software, hardware, and other relevant technological support; the market where the technology is diffused to its users; and the regulator creating the regulatory policies. These entities interact with each other according to their respective roles in implementing mobile technology in Indonesia.

1.2.1. Network Operators

Since the beginning of the cellular era, Indonesia's network operators have been mandated to deploy the network infrastructure throughout the country. To build the infrastructure, operators mainly use technological platforms provided by foreign vendors (i.e. Huawei, Ericsson, Nokia, and others), while local technological firms have not contributed significantly in terms of hardware deployment. Indonesians are subscribing to local mobile services, in which mobile handsets are easily obtained thanks to the free handset market situation. The mobile technology ecosystem is regulated by the national policymaker – the Ministry of Communication and Information Technology.

The early deployment of mobile technology in Indonesia began in 1994 when the country was introduced to 2G GSM technology by a national operator of Telkomsel and Indosat. During the 2G era, operators started rolling out the cellular network throughout the country. From 1997 to 2001, operators concentrated on efforts to respond to the Asian financial crisis. A steady cash flow was ensured by implementing vendor financing and deferring payments of all liabilities to vendors. However, during this period, operators were able to manage significant network development in consecutive years. Through such investment, operators carried out network expansion designed to support new subscribers every year, leading to increases in revenue.

In the 2G era, no firms supplied applications because voice was the main commodity. The operators' strategy was to use large channel infrastructure with voice traffic, then fasten revenue earnings. Research by Suryanegara and Miyazaki (2010), which characterised the Indonesian business model in the era of 2G, noted the domination of the free handset market – whereby users could easily buy a handset without having to bundle it with an operator's services. In Indonesia, users prefer not to bundle services and handsets. This has pros and cons as operators can focus on increasing the competitiveness of their service without needing to provide handsets to subscribers.

The period from 2006 to 2014 has been characterised as the emergence of data services – the era of 3G – when the three operators (Telkomsel, Indosat, Excelcomindo) launched the nationwide 3G WCDMA network in 2006. By 2008, Indonesia had 11 wireless telecommunication operators that used various 2G and 3G technologies; thus, mobile technology was successfully deployed throughout the country. During this era, the 3G business model was characterised by two main strategies: selling basic services (voice and SMS) and data (content and mobile broadband internet). For Indonesian operators, selling additional content was not very successful because cost was an obstacle that made users reluctant to access 3G content. Intense competition in the same market field forced Indonesian operators to be pragmatic, responding swiftly to competitors' actions. In the era of 3G, data was the commodity, but the multimedia content providers were not firmly established so the commodity was the internet itself.

In 2015, the country started deploying the 4G LTE Advanced network – initiating the era of 4G. During the 4G era, various firms supply both local and global digital content. By 2020, the network operators had experienced industrial merging and rationalisation, with six national operators surviving. The operators serve all populated areas, with Telkomsel controlling the largest market share. Table 3.2 provides details on the operators and technological platforms that provide cellular services in the country. It also shows that mobile technology is connected to 331 million subscribers, exceeding Indonesia's population of 270 million people.

Table 3.2 Indonesian Mobile Network Operator Indicators

Network	Service subscription brand (including once terminated)	Technology offered	Number of subscribers	Percentage of the market
Telkomsel	Simpati, KartU Halo, ByU, Kartu As, Loop	2G, 3G, 4G	171.1 million	51.7%
Indosat Oredoo	IM3 Ooredoo, GiG, Mentari	2G, 3G, 4G	59.3 million	17.9%
XL Axiata	XL Axiata, Axis, XL Prioritas	2G, 3G, 4G	56.7 million	17.1%

Network	Service subscription brand (including once terminated)	Technology offered	Number of subscribers	Percentage of the market
Hutchison 3 Indonesia	Tri	2G, 3G, 4G	30.4 million	9.2%
Smartfren Telecom	Smartfren	4G	13.3 million	4.0%
Sampoerna Telekomunikasi Indonesia (STI)	Ceria, Net1	4G	0.2 million	0.1%
Total			**331.0 million**	**100% of total subscribers**
				122% of Indonesian population

Source: Pusparisa (2020).

1.2.2. The Market

Indonesia's market ecosystem is characterised by 97% prepaid subscribers, and 90% are connected to 3G/4G technology as mobile broadband services. The behaviour of Indonesian market users is reflected in Table 3.3, which shows that they use broadband communications to access various applications, especially chats, social networks, and video applications. More than half the users use 3G/4G for shopping, and only a third use it for banking applications. The top 10 most frequently accessed applications (apps) originate abroad (e.g. WhatsApp, Facebook, and Instagram), while the only domestically made applications are Gojek and Tokopedia.

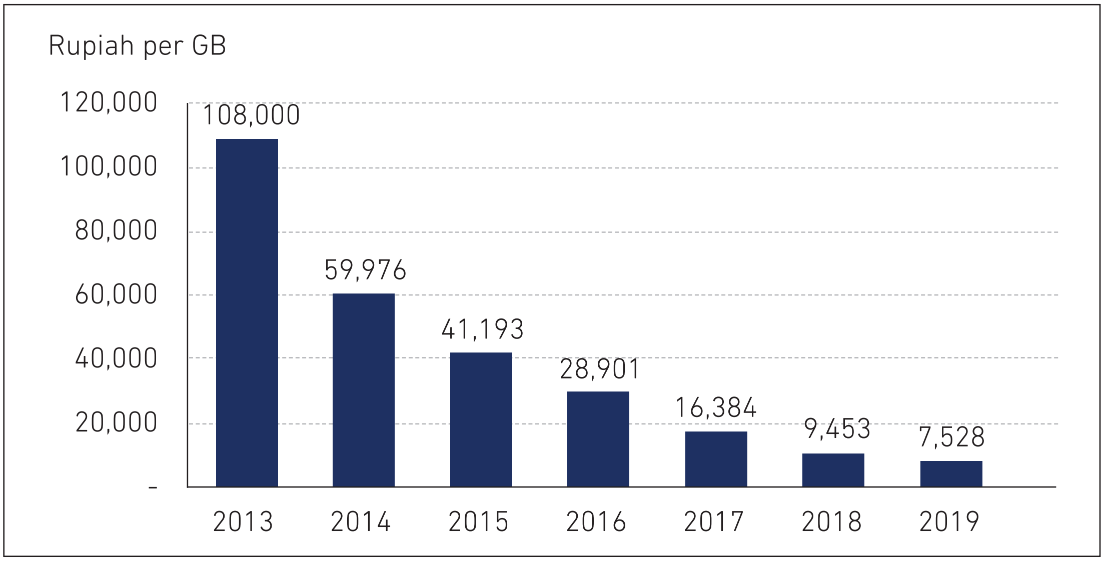
Table 3.3 Highlights of Indonesian Mobile Market Behaviour

Items	Highlights
Use of mobile apps	96% chat apps 96% social network apps 83% entertainment or video apps 55% shopping apps 33% banking apps
Top 10 mobile apps by active users	WhatsApp Messenger, Facebook, Instagram, Facebook Messenger, Line, Gojek, Shopee, Tokopedia

Source: Kemp (2020).

Consequently, the average data payload of the mobile market in Indonesia has increased significantly since 2013. In 2013, the monthly data payload per user was 0.1 gigabyte (GB) on average; whilst in 2019, the figure increased to 5.2 GB. During the same period, the global average monthly payload increased from 0.3 GB to 7.2 GB. The price of data use, measured by Rupiah per GB dropped rapidly as well. Based on statistics from Telkomsel, the telecom operator with the largest market share in Indonesia, the average price of mobile data use has decreased from Rp108,000/GB in 2013 to Rp7,528/GB in 2019. Since 2015, the total revenue generated by mobile data operating has surpassed that of voice operating. (Figure 3.2)

Figure 3.2 Average Price of Mobile Data Use



GB = gigabyte.

Source: Telkomsel (2022).

In terms of the relationship between 5G technology and the forthcoming market, research conducted in 2020 (Suryanegara, 2020) revealed what type of innovation is required to provide appropriate infrastructure and services for 5G deployment in Indonesia. The answer to this question depends on the pattern of innovation enhancement – defined as factors arising from market disorder and uncertainty that can lead the way to successful diffusion of 5G technology in that market.

Suryanegara (2020) analysed the pattern of 5G innovation enhancement (Figure 3.3) and found that the Indonesian market has kept demanding a higher data rate in all market segments. Considering the country's topography, satellites and drones can be regarded as disruptive innovation of the 5G network infrastructure to cover remote areas. As the global trend also comes with non-cellular connectivity (such as Wi-Fi), the market also expects non-cellular connectivity – aiming to be able to access free service applications. This can be to the fact that cellular data tariffs are still deemed expensive for most of the market. To support the ecosystem, the Indonesian market needs better handsets as users mostly access data, but the voice quality over the 5G network is still considered important. Finally, the market also reflects the concern that 5G should increase users' confidence in security and privacy.

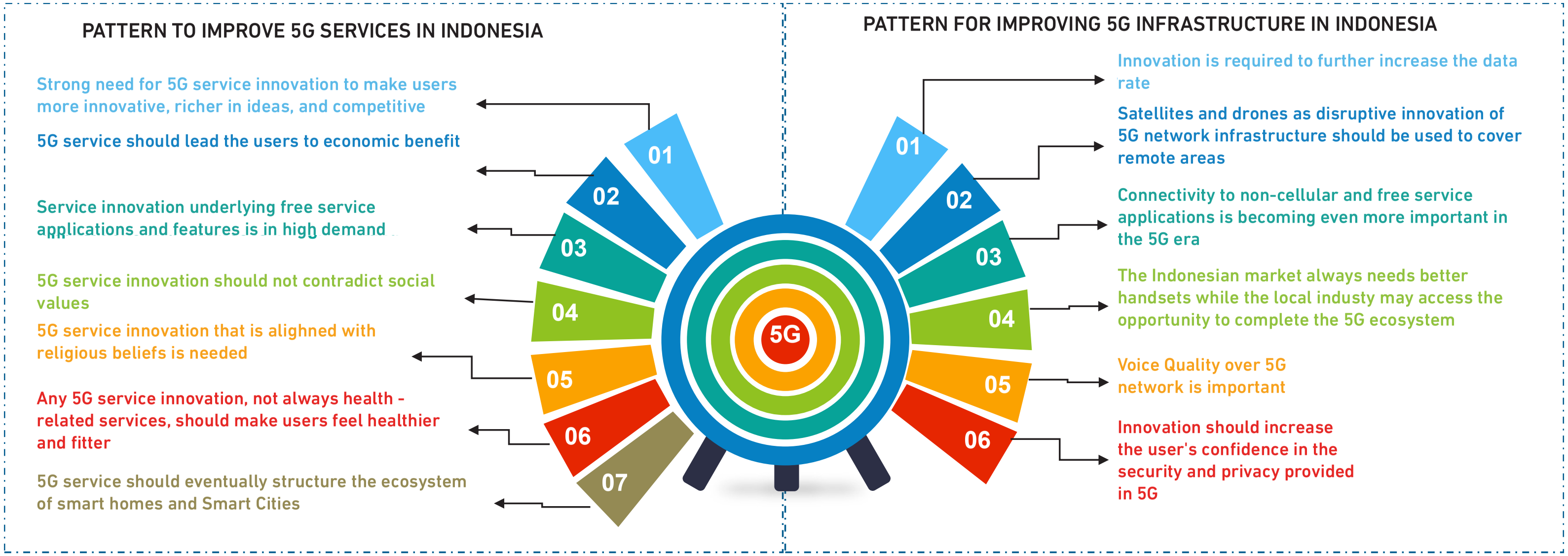
From the perspective of final benefits, Figure 3.5 emphasises that the Indonesian market expects the emergence of 5G to lead users to economic benefits and improved social values. There is a major expectation that any service innovation should not contradict society norms, and as a religious society, it should be in accordance with religious beliefs. This creates opportunities for service developers to provide a new stream of application content matching the values of local people in Indonesia.

1.2.3. Technological Suppliers

The technological supplier, commonly referred to as the vendor, is the actor in the ecosystem providing network technology for network operators and handset technology for the Indonesian market. Leading European information and communication solutions providers, such as Ericsson, Nokia, Motorola and Siemens, entered the Indonesian market at the early stage when cellular technologies were introduce to the country, and dominated the market of mobile phones in the 2G era. Apple and Samsung joined the competition and quickly took the lead of the market when the 3G technology became the mainstream. Their domination continued to the 4G era. But Chinese brands, such as Huawei, ZTE, XIAOMI, VIVO and OPPO, have been on the rise and getting Indonesian users' favor. Nexian was the first Indonesian brand during the 3G era, while Polytron is another local brand that has survived in the era of 4G.

The existence of foreign technology suppliers is clearly indicated by data on import values – the import value of Indonesia's telecommunications equipment was $2.2 billion in 2019. This value is 1.2% of the total import value and 0.1% of the GDP in Indonesia. At the beginning of the 4G era, imports reached a peak of $6.3 billion in 2013, which is 3.3% of the total import value and 0.6% of Indonesian GDP. This phenomenon indicates that the Indonesian market and industry are very excited, but they were dominated by imports. The import value of telecommunications equipment averaged $4.4 billion per year from 2003 to 2019 (CEIC, n.d.).

Figure 3.3 Pattern of 5G Innovation Enhancement in Indonesia, 2020



Source: Suryanegara (2020).

Selected technical profiles of the Indonesian mobile network are shown in Table 3.4. More than half a million base transceivers provide capacity of 2.5 million terabytes. The current use is around 96% of the total capacity, which is critical as it has almost reached the peak value. On the other hand, the need for capacity is increasing along with people's online behaviour, so it is necessary to provide additional spectrum frequency band for the operators.

Table 3.4 Technical Profile of Mobile Networks in Indonesia in 2020

Mobile technical parameters	Number
Total spectrum used by the operators	467 MHz
Number of base stations	521,329 unit
Monthly national capacity (provided)	2,650,592 terabytes
Monthly capacity per user (used)	7.2 gigabytes
Monthly national capacity (used)	2,485,440 terabytes (94% of total provided)

MHz = megahertz.

Source: Author (compiled from operators' reports).

1.3. INDONESIA'S MOBILE CELLULAR TARGET: BUILD UP INFRASTRUCTURE

The strategic plan for 2020–2024 of the Ministry of Communication and Information Technology, the mobile regulatory policymaker, states that the first strategic objective is to establish infrastructure and accelerate the rollout of Information and Telecommunications Technology (ICT) infrastructure to the entire territory of Indonesia. This indicates that the Government of Indonesia has made infrastructure the foundation of national digitalisation. The focus is for infrastructure to guarantee access to communication technology for all Indonesians. As an archipelagic country, half of the country's population live in 74,957 villages in rural areas. Cellular coverage has reached more than 97% of those populated areas, but broadband access (4G-based technology) is still concentrated in commercial areas such as Java, Sumatra, and parts of Kalimantan – leaving areas unserved by access telecommunications in non-commercial areas. There are 12,548 villages that have not been served by a full 4G cellular signal, of which 3,435 are in areas that are classified as the outermost and isolated locations, commonly known as 3T (*tertinggal, terluar, terpencil*) areas. The government is eager to rectify this unfair distribution and connect people in these locations by building up mobile broadband infrastructure in non-commercial areas so that 4G internet can be provided immediately.

The second strategic objective is to accelerate digital transformation in the application framework for industry, governance, and community utilisation. For this reason, it is very important for Indonesia to be able to provide high-speed mobile broadband services that support these various applications. The Speedtest Global Index in January 2020 ranked Indonesia's mobile broadband internet 120th in the world, with an average download speed of 14.16 Mbps and upload speed of 9.50 Mbps – below the global average (download speed of 31.95 Mbps and upload speed of 11.32 Mbps). For fixed broadband speed, Indonesia was ranked 115th with a download speed of 20.60 Mbps and an upload speed of 12.53 Mbps – still far below the global average (74.32 Mbps for download and 40.83 Mbps for upload).

1.4. CHALLENGES AND OPPORTUNITIES FOR UPGRADING MOBILE NETWORK IN INDONESIA

5G technology will bring the network to the next stage. Mobile network operators in Indonesia realise that to keep pace of technology progress, they must know invest more in developing the latest 5G technology. How to cultivate the new market seems challenging – the market needs continuity to grow, but the pace of technology updates seems too fast to catch up with. Moreover, the development and the update of ICT infrastructure needs intensive capital input. It is critical to create new demand and motivate the market to adopt the new generation technology.

Cellular phones are the main tool for most Indonesian internet users – 96% of internet users use their mobile phones to access the internet. When going shopping online, 91% use mobile access compared with 22% who use personal computers/desktops. (Table 3.5). This tells us a two-sided story. On the one side, such high dependence on the mobile network must thank to the country's rapid technology adoption and substantial economic growth. On the other side, the coverage and quality of fixed broadband infrastructure are still relatively low when compared to many other Asian countries. That is, the alternative for users to move from the mobile network to the fixed broadband network is limited, and when the network upgrades to 5G, it is likely that most users will arm themselves to adopt it. This could be an advantage for Indonesia in terms of upgrading its mobile network, as far as the cost of upgrade and transition is affordable.

Table 3.5 Overview of Internet Access in Indonesia

Situation in January 2020	Remarks
175.4 million internet users	• Users may access the internet from various devices, i.e. mobile phones (96%), smartphones (94%), mobile phones (21%), computer desktops (66%), and tablets (23%). • Internet users increased by 17% or 25 million per year.
160.0 million social media users	• Social media users increased by 12 million (+8.1%) from April 2019 to January 2020. • Social media penetration was 59% in January 2020.
338.2 million mobile connections	• Mobile connections increased by 15 million (+4.6%) from January 2019 to January 2020. • The number of mobile connections in January 2020 was equivalent to 124% of the total population.

Source: Author, based on Kemp (2020).

2. INDONESIAN PROFILE OF TECHNOLOGY – INTERNET OF THINGS

2.1. TECHNOLOGICAL OVERVIEW OF IOT

IoT is a network of objects connected to the internet. IoT can be described as a world in which objects can feel, communicate, and share information with one another through public or private internet Protocol (IP) networks (Patel, Patel, and Scholar, 2016). These interconnected objects have data that are regularly collected, analysed, and used for decision making. The goal of IoT is to connect objects to the internet anytime and anywhere.

In the Agriculture industry, IoT can be used to detect the number of livestock in real time, sense soil moisture and quality, sense room temperature to maintain food quality, and maintain food supply chains by using the IoT tracking application. The value of IoT in this industry is predicted to be 34.9 billion by 2027 (GlobeNewswire, 2020). WEF (2018) projected that adopting IoT in the manufacturing industry (i.e. automotive and transportation, pharmaceutical[2]) will increase value added of around $14 trillion in 2030.

[2] IoT can help maintain the quality of chemicals or medicines through sophisticated storage media such as temperature, pressure, and other sensors that are useful for maintaining the quality of drugs in storage media; and the continuity of medical drug production.

The potential benefit of IoT adoption will be even bigger in the non-manufacturing industry, especially service sectors such as medical and healthcare, retail, logistics, supply chain management[3] and environmental monitoring.

IoT will also have wide application in our daily life. For example, IoT can help improve home automation by collecting and processing real-time data related to room conditions such as temperature and humidity; detect objects, animals, and humans outside the home via home surveillance; and control home appliances using applications connected to the internet. IoT is the backbone of smart cities – it helps manage cities more effectively through applications such as traffic lights that are directly integrated with sensors and using video surveillance system to monitor vehicle flows, vehicle plates, and speed limits; and to regulate traffic. By doing so, adopting IoT can make the public administration more efficient and energy efficient.

IoT platforms can be classified based on parameters such as the data transmission rate or transmission distance. Based on the data transmission rate, IoT communication services can be classified into two categories: high-speed data services (e.g. video services) and low-speed data services (e.g. metre readings). Based on the transmission distance, IoT communication technology can be classified into two categories: short-distance communication and long-distance communication (commonly referred to as a wide area network (WAN)).

The most popular platform is IoT services that have low data rates and cover a large area – low-power wide-area network (LPWAN) technology. LPWAN technology can be classified based on the operating spectrum frequency band. The technology may operate in the licensed spectrum as well as the non-licensed spectrum. Examples of technologies that work in the non-licensed spectrum are LoRa and Sigfox. While the Narrowband Internet of Things (NB-IoT) platform works in the licensed spectrum of 3G and 4G, Table 3.6 compares Sigfox, NB-IoT, and LoRa.

[3] The value of IoT in this industry is predicted to reach $100.9 billion by 2030. (Research and Markets, 2020)

Table 3.6 Technical Comparison of IoT Platforms – Sigfox, NB-IoT, and LoRa

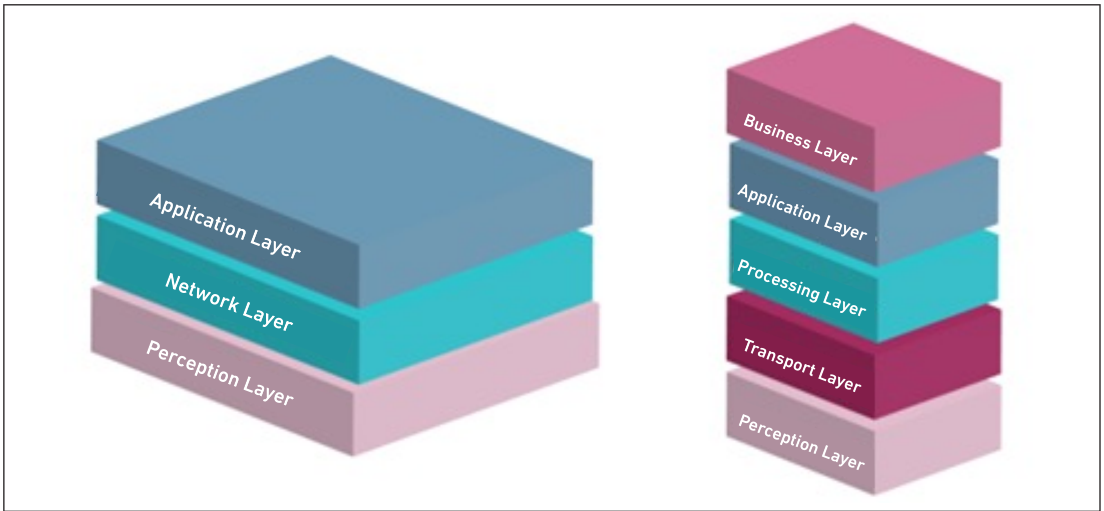
Item	Sigfox	NB-IoT	LoRa
Standard	Sigfox	3GPP	LoRa Alliance
Modulation	BPSK	QPSK	CSS
Frequency	ISM (433 MHz, 868 MHz, 915 MHz)	Licensed on LTE band	ISM (433 MHz, 868 MHz, 915 MHz)
Coverage (Tx radius)	10–40 km	2–20 km	1–10 km
Bandwidth	100 Hz	200 kHz	125 kHz, 250 kHz
Tx limit	140 packet per-day	Unlimited	Limit duty cycle
Maximum data rate	100 bps	200 kbps	50 kbps

bps = bit per second , BPSK = Binary Phase Shift Keying, CSS = Chirp Spread Spectrum, Hz = hertz, IoT = internet of things, ISM = industrial scientific and medical , kbps = kilobit per second , kHz = kilohertz, km = kilometre, LTE = Long-Term Evolution, MHz = megahertz, NB-IoT = Narrowband Internet of Things, QPSK = Quadrature Phase Shift Keying, Tx = Transmitter.

Source: Author's compilation.

There is no universally agreed IoT architecture. Three- and five-layer architectures are the most commonly used (Sethi and Sarangi, 2017). These are divided into three basic layers and five special layers, as illustrated in Figure 3.4.

Figure 3.4 Three- and Five-Layer IoT Architecture



Source: Author, based on Sethi and Sarangi (2017).

The three-layer architecture defines the main idea of IoT under the following layers:

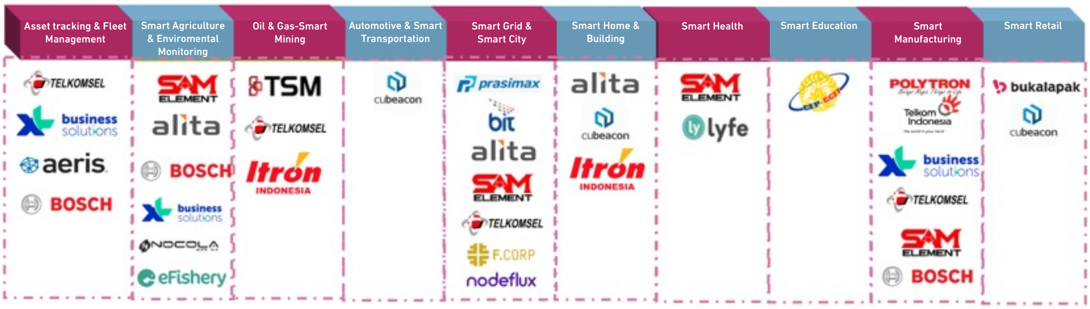
i. Perception layer: a physical layer that has sensors to gather information about the environment around it. The sensor also detects physical objects in the surrounding environment.
ii. Network layer: responsible for connecting smart devices, network devices, and servers. The feature is also used to transmit and process sensor data.
iii. Application layer: responsible for delivering specific application services to users. It defines the various applications in which IoT can be used, e.g. smart home, smart city, and smart healthcare.

The five-layer architecture is a more complete or specialised architecture that offers a more detailed version of the three-layer architecture. It adds the transport layer to the perception layer – to transfer sensor results from the perception layer to the processing layer. The processing layer is an extended version of the network layer, which functions as middleware on the application layer side where there are many technologies such as databases, cloud computing, edge computing, and big data processing. The top layer is the business layer, which plays a role in managing the system.

2.2. INDONESIA'S IOT ECOSYSTEM

The IoT market in Indonesia is expected to reach Rp444 trillion by 2022 and Rp1,620 trillion by 2025. About 70% of the state budget will be supported by IoT-based industries. Indonesia currently has around 250 companies involved in the Indonesian IoT ecosystem. Figure 3.5 illustrates the Indonesian blueprint of a smart IoT ecosystem.

Figure 3.5 A Smart IoT Ecosystem in Indonesia



Source: ASIOTI (2020).

The IoT Indonesian Association identified three different types of roles in the ecosystem (ASIOTI, 2020). The main task of the network providers is supplying the hardware, network infrastructure, and operating platform. Foreign technology suppliers (e.g. Huawei, Nokia, and ZTE) provide the hardware, while local firms (e.g. Telkomsel, Indosat, XL Axiata, and PT Telkom) act as the network providers. Regarding the use of wireless platforms, the network providers also deal with spectrum regulatory issues – e.g. the IoT unlicensed spectrum for the LoRA platform works on 920–923 megahertz (MHz) in Indonesia. The second is undertaken by IoT service enablers, including mobile virtual network operators, IoT service delivery platforms, and firms providing deployment support. A local Indonesian company performing this role is Alita, which provides payment machine systems for the commuter railway express throughout Jakarta. The third is undertaken by companies that provide IoT applications such as Prasimax, DycodeX and Intel.

2.3. IOT IN SUPPORTING INDONESIAN INDUSTRY 4.0

In IoT technology, the government's work is driven by the Ministry of Industry, as the government views the role of IoT technology in supporting the digital transformation mainly in terms of the industrial sector. This is inseparable from the evolution of Industry 4.0, which makes IoT one of its core technologies. The establishment of an Indonesian IoT ecosystem will rely heavily on the government's commitment to implementing the 'Making Indonesia 4.0 roadmap' – an integrated roadmap to implement strategies to enter the Industry 4.0 era, developed in 2019 to achieve targets by 2030. Five sectors will serve as pilots to strengthen the fundamentals of the country's industrial structure to operationalise the roadmap: (i) food and beverage industry, (ii) automotive industry, (iii) electronic industry, (iv) chemical industry, and (v) textile industry.

The food industry has the biggest total investment (both foreign and domestic), at about Rp302.8 trillion. This is followed by basic metal, metal goods, machines, and electronics (Rp299.0 trillion); basic chemicals, chemical goods, and pharmaceuticals (Rp285.5 trillion); and other transportation industry (Rp160.3 trillion). The textile industry, as the last component of the main Industry 4.0 sectors, is in eighth place with total investment of Rp58.3 trillion (Ministry of Investment, n.d.).

Following this strategy, the country regards IoT technology as a platform for transforming Indonesian industry. Thus, such technological development is directed at the creation of application use cases that could be beneficial for Indonesian industry.

2.4. CHALLENGES AND OPPORTUNITIES FOR IOT DEVELOPMENT

The main challenge for Indonesia is to create an ecosystem involving heterogeneous types of corporate, small, medium-sized, and large technology developers. From the technology implementation point of view, the IoT network is still not perfectly formed. For its openness and easiness, the LoRa network is expected to be widely deployed. NB-IoT infrastructure has not been implemented well, although it could be a new revenue source for cellular operators. Industry is more enthusiastic about developing LoRA-based use cases and private IoT networks circulating in the community.

On the other hand, opportunity lies in the creation of IoT service applications for multiple market segments – especially for small and medium-sized enterprises (SMEs). There are around 3.7 million SMEs in Indonesia, making them the most potential users of IoT service applications. This is in line with an optimistic view that IoT creates significant opportunities for Indonesia because this technology will be effective if the solutions it offers are specific and local, i.e. based on the problems that exist in Indonesia.

In terms of non-industrial applications, Suryanegara et al. (2019) indicated the varied uses of IoT in the public sector. The strategic implications of these findings concern niche markets, for which prospective IoT operators must pay close attention to the types of applications desired by the market. Sometimes, the desired applications are not mainstream but rather are focused on specific demands. Research has shown that more than 50% of the Indonesian market wants IoT applications that benefit their jobs, while about 13% of respondents want IoT applications that provide benefits for domestic work. An interesting finding is that about 9.52% of respondents want IoT applications that will be beneficial in improving the quality of their family relationships. In addition, 5.24% of Indonesians feel that IoT technology could contribute to their religious lives.

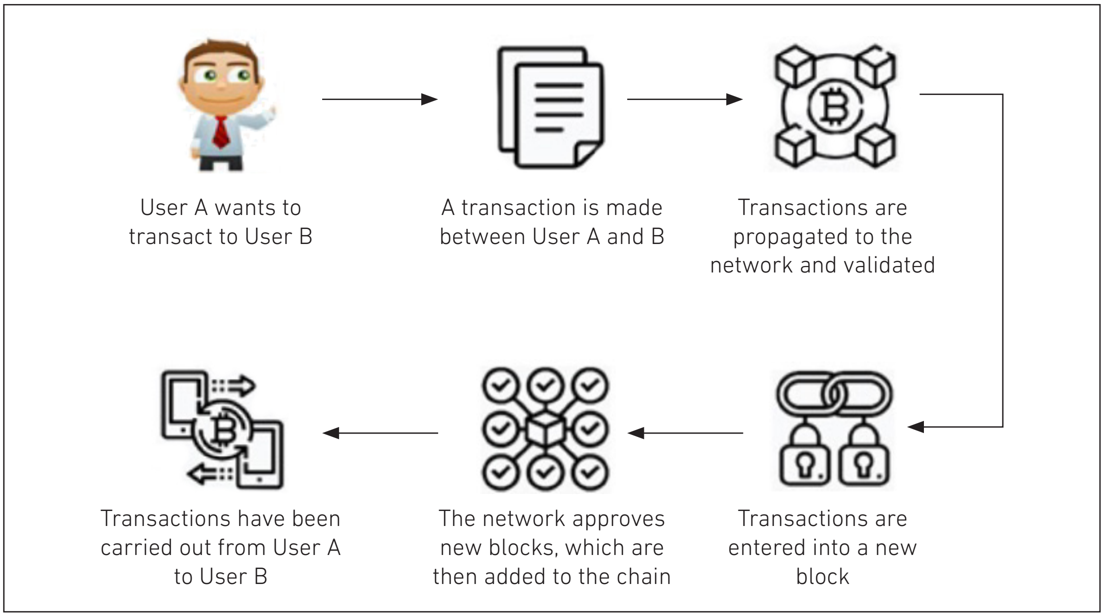
3. INDONESIAN PROFILE OF TECHNOLOGY – BLOCKCHAIN AND CRYPTOCURRENCY

3.1. TECHNOLOGICAL OVERVIEW OF BLOCKCHAIN AND CRYPTOCURRENCY

Blockchain is a decentralised ledger, originally used to record digital currency transactions on a digital currency network in a peer-to-peer (P2P) manner. This technology was developed by Satoshi Nakamoto as Bitcoin (Nakamoto, 2008). The system used by Bitcoin does not require a centralised server to store transaction history. Instead, it only stores a copy of the blockchain in all nodes of the blockchain network, making it a decentralised ledger. Each node has a copy of the ledger. Transactions are verified using public and private-key cryptography before adding new blocks to the blockchain network (Hackius and Petersen, 2017). Each transaction is carried out, starting with the necessary information regarding the sender, recipient, time, transaction information, and identification of the transaction from the previous sender (Gemeliarana and Sari, 2018).

Figure 3.6 illustrates a sample cryptocurrency flow: when user A wants to make a transaction to user B through the blockchain network in a P2P manner, the identity of the cryptographic proof is used, which is a pair of public keys and private keys on the network that can identify that user A and user B are unique. The transaction is broadcast to the memory pool on the blockchain network to verify and validate it. Then a number of approved nodes are obtained, and a new block is generated, which is also known as reaching the consensus stage. After reaching the consensus stage, new blocks across the blockchain network are formed, and each node in the blockchain network updates its respective ledger. This block contains all transactions that have occurred by following the original block on the blockchain network through a digital signature.

Figure 3.6 **Method of Blockchain Operation**



Source: Kückelhaus and Chung (2018).

In reaching the consensus stage, a consensus algorithm is used – i.e. it occurs when the P2P network has reached consensus on the distribution of the ledger that has occurred. Each existing node can choose CPU power to receive a valid block by fetching or rejecting an invalid block. Each transaction on the block is marked with a specific timestamp and blockchain data continue to grow, which means that the blockchain is a distributed variant that adapts the timestamp service.

The function of the cryptographic hash of the blockchain is usually called the secure hash algorithm 256 (SHA256). This function can generate a 16-digit hash using the sender's public key and transaction information. This encrypted transaction information is translated to verify whether the transaction was made by the sender, and the transaction can only be decrypted by the recipient who has the public key/private key (Chen et al., 2018). Each block has three core components: hash from the previous block, timestamp, and hash. The hash of the previous block is linked to the entire blockchain so the block cannot be updated once the block has been verified and validated. Changing the value of transactions that have been verified by all nodes will be difficult because hackers must obtain 51% or more of all computing power in the blockchain network/system (Tijan et al., 2019). Each new block verifies the previous block, so this mechanism makes the blockchain more immune to malicious activities.

3.2. INDONESIA'S BLOCKCHAIN AND CRYPTOCURRENCY ECOSYSTEM

From the theoretical explanation above, we know that blockchain technology cannot be separated from cryptocurrency. In fact, blockchain can be used for projects in many sectors, including the telecommunications industry, environmental surveillance, transportation, banking, agriculture, and even government. In Indonesia, this technology is growing – mainly driven by Bank Indonesia as the central bank and by major national banks.

The implementation of blockchain technology is also generally induced by the creation of a new form of trust. Therefore, the application of blockchain can redefine trust so that it can bring about an evolution of 'minimisation of trust' in dealing and transacting between humans. The government considers that blockchain technology could foster digitalisation of the government service platform, and ultimately increase trust in – and the transparency, effectiveness, and efficiency of – government administration. Another benefit of implementing blockchain is the utilisation of smart contracts, which will facilitate governance in tax supervision and compliance. In terms of technology users, blockchain has the concept of 'redistribution of value', whereby the concentration of technology users tend to decentralise.

In the financial sector, blockchain and crypto assets have grown exponentially in Indonesia since 2015. The estimated number of traders in Indonesia reached more than 1.5 million in 2020, increasing by 2,263% from 2015. Cryptocurrency has operated legally since 2019, and at the end of 2020, the Commodity Futures Trading Regulatory Agency (Bappebti) recognised 229 cryptocurrencies that can be traded on the physical crypto asset market, including Bitcoin, Ethereum, Tether, XRP/Ripple, Bitcoin Cash, Binance coin, Polkadot, and Chainlink. Even in the third quarter (Q3) of 2020, Rp22,671 trillion was recorded in crypto transactions in Indonesia. Table 3.7 shows the growth of the blockchain and crypto asset industry in Indonesia from 2017 to 2020.

Table 3.7 **Blockchain and Crypto Asset Industry Growth in Indonesia, 2017–2020**

2017		2018		2019		2020(until Q3)	
Asset	Total	Asset	Total	Asset	Total	Asset	Total
Bitcoin	16,032	Bitcoin	16,847	Bitcoin	11,905	Bitcoin	10,087
Bitcoin Cash	6,969	Stellar	9,814	Ethereum	2,233	Tether	1,894
Zcoin	6,236	Ripple	6,013	Tron	1,107	Ethereum	1,781
Stellar	5,068	Tokenomy	5,859	Ripple	920	Dogecoin	930
NXT	4,131	Ethereum	4,265	Dogecoin	686	Aurora	653

Source: Asosiasi Blockchain Indonesia (2020), 'Indonesia Crypto Outlook Report'. Jakarta: Asosiasi Blockchain Indonesia. https://asosiasiblockchain.co.id/wp-content/uploads/2020/09/Indonesia-Crypto-Outlook-2020-Report.pdf.

3.3. BLOCKCHAIN IN SUPPORTING THE FINANCIAL SECTOR

The government's target for the implementation of blockchain technology in the financial sector is undefined as the technology is nascent. However, we can identify the service behind the emergence of this technology – fintech applications. Indonesian financial inclusion was 67.0% in 2017 and 76.1% in 2019, lagging many of Indonesia's neighbours, while the government has set a target of 90.0% by 2024 (Hu and Isjwara, 2021). Therefore, access to financial services – including the means to save, grow, and use one's wealth – is a key part of the Indonesian initiative to reduce poverty and promote more inclusive economic growth.

Fintech is the use of technology in the financial sector or the implementation of technology in financial services (Wulan, 2017). According to the International Organization of Securities Commissions (IOSCO), fintech is divided into eight categories: payment, insurance, lending and crowdfunding, planning, trading and investment, blockchain, data and analytics, and security (IOSCO, 2017).

The security as a service feature is a crucial element of all fintech services (Tuan, 2020). To ensure such a security feature, blockchain technology is used as the base of the security platform, along with encryption, biometrics, multifactor authentication, and other security systems.

Indonesia has large fintech opportunities because it is home to a largely cash-based community, and huge swaths of the population – up to 80% – remain unbanked. Great potential can be seen from the fact that the value of electronic money transactions surged by 207% in 2019 to Rp145.2 trillion and nearly nine out of 10 internet users in Indonesia use a digital wallet (Jakpat, 2020).

3.4. CHALLENGES AND OPPORTUNITIES

The technology of blockchain and fintech is still mainly driven and determined by the financial sector. The ideal condition is for all sectors to continue to be enthusiastic about developing relevant services, such as blockchain, for logistics and other areas. Yet, with the fourth largest population in the world, all kinds of economic and financial transactions will have big implications. The correlation is that fintech will be encouraged to grow along with community activities.

Indonesia had 115 banks in 2020, with total money supply of around Rp1,855 trillion. Meanwhile, money supply circulating in the public, outside banking, totalled Rp760.0 trillion. This reflects the growth potential for fintech services in Indonesia. Since 53% of Indonesia's population already shops online and uses a digital financial platform, the financial sector can be a leader in the transformation of society. Thus, the technology utilisation relevant to this sector is in relation to the financial platform, while strengthening of related technology is necessary.

Table 3.8 provides basic data on Indonesian financial inclusion, showing the country's potential for the growth of fintech operations. Only 48.0% of the Indonesian adult population has access to a banking institution, while 3.1% have a mobile money account and 11.0% pay bills online. On the other hand, 168.3 million Indonesians purchased consumer goods online in 2019.

Table 3.8 Basic Data on Indonesian Financial Behaviour as a Fintech Opportunity

Factors	Basic data
Financial inclusion	**Reference adult population in Indonesia** • 48.0% have an account with a financial institution • 2.4% have a credit card • 3.1% have a mobile money account • 11.0% make online purchases or pay bills online
Online purchase of consumer goods	• 168.3 million people purchased consumer goods online in 2019 • $18.76 billion market value for online consumer goods • $111 average annual revenue of the shopper • 2.9% of GDP per capita of the online consumer goods ARPU
E-commerce purchases by payment method	• 35% using credit cards • 13% using cash • 24% via bank transfer • 14% using an e-wallet

ARPU = average revenue per user , GDP = gross domestic product.

Source: Author, based on Kemp (2020).

In particular, fintech lending (or P2P lending) received increasing attention in Indonesia. Fintech lending is a type of service that provides loan funds to businesspeople who want to develop their own businesses and manages funds from investors who are willing to lend to businesspeople. There are two types of fintech lending: conventional fintech lending and sharia fintech lending. Indonesia has 149 conventional fintech lending companies and only 12 Islamic sharia fintech lending companies. Since Indonesia is the largest Muslim country in the world, it presents a significant opportunity in the financial industry in terms of Islamic finance.

4. INDONESIAN PROFILE OF TECHNOLOGY – ARTIFICIAL INTELLIGENCE

4.1. TECHNOLOGICAL OVERVIEW OF AI

AI is a field of computer science that emphasises the creation of intelligent machines/robots that work and react like humans (Marr, 2018). It can be integrated with various cognitive functions, such as language, attention, planning, memory, and perception. Recent research on AI – including machine learning, deep learning, and predictive analysis – intends to improve the planning, learning, reasoning, thinking, and acting abilities of machines (Shabbir and Anwer, 2018).

To bring AI into real applications, mathematical and algorithmic analytic core technology is transformed into computer language programming. Such computer language programs are then built into AI software or service applications, as well as AI hardware products. AI applications may range from simple decision-making software for business to complicated robots for space missions.

There are four types of AI or AI-based systems: reactive machines, limited memory machines, theory of mind, and self-aware AI (Joshi and Cognitive World, 2019).

i. Reactive machines are the oldest type, indicated by a non-memory capacity that only responds to different stimuli. A popular example of a reactive AI machine is IBM's Deep Blue, a machine that beat chess Grandmaster Garry Kasparov in 1997.
ii. Limited memory machines refer to a type of AI that is capable of learning from historical data to make decisions. Examples of this application are chatbots and virtual assistants for self-driving vehicles.

iii. Theory of mind AI is the next level of AI systems that researchers are innovating. It will be able to better understand the entities it is interacting with by discerning their needs, emotions, beliefs, and thought processes. Robotic technology that is made to help people's daily work is an example of this category.
iv. Self-aware AI currently exists only hypothetically. It has human-like intelligence and self-awareness. It mimics the concept of a human brain that has developed self-awareness, and not only evokes emotions in those it interacts with but also has emotions, needs, beliefs, and potentially desires of its own.

4.2. AI ECOSYSTEM IN INDONESIA

The current development stage of AI ecosystem in Indonesia still falls in the limited memory category. The relevant technologies are supported by well-known branded AI software platforms provided by foreign technology suppliers (e.g. Google Tensor Flow, IBM Watson, and Microsoft Azure) as well as software for data visualisation (e.g. Tableau and Microsoft Power BI). However, as the nature of AI mainly works on the basis of software programming, many local start-ups may develop unique applications using programming languages such as R, Python, JAVA, Lips, and Prolog. The programming languages finally create AI-based service applications, which are diffused into large corporate and governmental agencies. Table 3.9 shows some prominent Indonesian AI start-ups and samples of the users of their service applications.

Table 3.9 Indonesian AI-Based Service Applications and Users

<table>
<tr><th>AI Indonesian start-ups</th><th>Main service applications</th><th>Large companies using the services</th></tr>
<tr><td>Bahasa.ai</td><td>Developing conversational modules based on NLP/NLU with specific Indonesian language specifications.</td><td rowspan="5">Bank Sinarmas, Dana, Smartfren, Panorama JTB, Johnson & Johnson, Unilever, P&G, Nestle, Uber, Skyscanner, Zomato, Telkomsel, BRI, dan Unilever, Facebook, OVO, BNPB, COVID-19 task force in Indonesia, Suzuki Finance, BCA, Indonesia's National Police (POLRI), NVIDIA, Highway Toll Operator Jasa Marga, HP Enterprise, IBM, Asian Games 2018 Committee, and IMF–World Bank 2018 Committee</td></tr>
<tr><td>Snapcart</td><td>Developing mobile application that gives shoppers cashback for scanning their receipts. Analysing it and offering real-time insights and analytics to the company regarding its purchase data.</td></tr>
<tr><td>BJTech</td><td>Developing Indonesian chatbots for business, virtual friends, and an intelligent banking app.</td></tr>
<tr><td>Datanest.io</td><td>Offering data science services and AI customisation</td></tr>
<tr><td>Kata.ai</td><td>Developing conversational AI solution applications supported by NLP/NLU such as light conversations and virtual assistants, answering frequently asked questions, and personalised product offerings; can be integrated with various chat applications, including WhatsApp.</td></tr>
</table>

AI Indonesian start-ups	Main service applications	Large companies using the services
Konvergen.ai	Developing data entry applications by using AI technology, a service to observe and analyse consumer behaviour in more detail.	
Nodeflux	Developing AI-based solutions, including face mask detection, physical distancing, and public mobility monitoring.	
Pind.ai	Developing artificial visual and IoT systems such as visual computing, facial recognition, and machine learning; and analysing big data.	
Prosa.ai	Developing AI services for Indonesian text and voice processing services, customer interaction analysis, business optimisation, fraud detection, image processing, chatbot services to convey information about COVID-19, and social media monitoring.	

AI = artificial intelligence, COVID-19 = coronavirus disease, IoT = internet of things, NLP = natural language processing, NLU = natural language understanding.

Source: East Ventures (2019).

4.3. INDONESIA'S AI ROADMAP

In 2020, the Ministry of Research and Technology established an AI Indonesia roadmap that focused on five main areas (BPPT, 2020). If the government is committed to implementing this roadmap, it is hoped that the creation of AI technology may come from local industry and academia, then increase the widespread adoption of AI technology in the industrial and public sectors.

The five priority areas identified by the government are:

(1) Health: supporting a predictive, preventive, personal, and participative (4P) health framework. AI has an important role to play in processing and providing insights from big data collected through genetics and sensors within the 4P health framework.
Sample targets:
- using big data analytics and AI to build alert systems for the spread of the coronavirus disease (COVID-19) using applications and machine learning
- easing access to the availability of health facilities using a conversion interface
- providing recommendations for access to and use of medical facilities and personnel
- providing recommendations for pandemic prevention

(2) Bureaucratic reform: driven to be in line with Presidential Regulation No. 95 of 2018 on Electronic Based Government Systems (SPBE). The goal is realising clean, effective, transparent, and accountable governance – as well as quality and trusted public services – through support for the use of ICT in an integrated government system.
Sample targets:
- developing a chatbot platform for government services
- developing AI for government budget management to detect irregularities in government budgets, which will facilitate evaluation
- personal identification using face, voice, and other types of biometric recognition
- sentiment analysis, which makes use of data from social media to identify the perception of society towards government policy or the implementation of government programmes
- big data governance analysis that uses data from multiple sources – both structured data held by the government as well as unstructured and dynamic data taken from various social media and internet sites – to assist the government in decision-making

(3) Education and research: forming reliable human resources. The government plans to boost the creation of AI platforms to support the education and research activities.
Sample targets:
- providing intelligent online education by developing multimedia content, educational games, and adaptive assessments for learning as a fun experience, not as a burden
- developing smart course content with augmented and/or virtual reality, and virtual laboratories
- developing an adaptive learning system that adapts to students' abilities – students will be provided material according to their abilities, with a difficulty level that can be increased or decreased based on the evaluation results
- creating an adaptive assessment system and intelligent student classification that classifies students based on certain abilities so that the provision of subject matter can be adjusted to the class

(4) Food security: creating advantages for Indonesian people by using relevant applications to strengthen national food security.
Sample targets:
- providing alert systems for types of food that are in short supply and need to be restocked
- providing recommendations for access to and use of food through demand and balanced supply for each region

- increasing land productivity and using resources more efficiently
- achieving financial inclusion of low-income farmers
- using satellite images to determine disadvantaged areas, identify the commodities grown in an area, and provide harvest predictions for each commodity
- predicting harvest failures from historical data combined with variables such as weather, and anticipating the spread of new food diseases to minimise crop failures
- predicting food stocks and its relevant recommendation – AI can be used to predict the stock of staples throughout a city and relocate food availability so that no area experiences food shortages

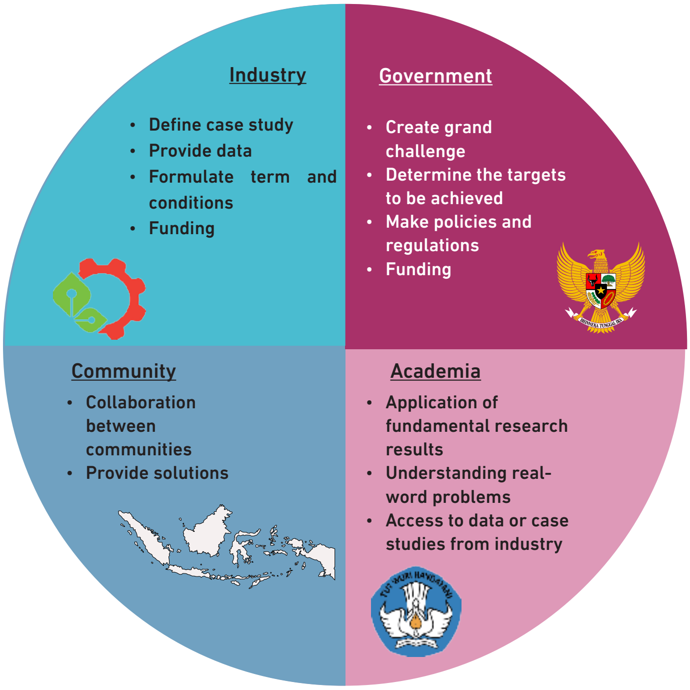
(5) Mobility and smart cities: helping the government establish smart cities.
Sample targets:
- using AI for intelligent traffic management
- using AI for intelligent waste management
- using AI for disaster risk management
- using AI for citizen information management
- using AI for quality assessment of contractors
- using AI for spatial management
- using AI for operational management of public facilities

4.4. CHALLENGES AND OPPORTUNITIES

The development of AI technologies and the application of AI are still constrained by the lack of qualified human capital. Indonesia still has insufficient human resources in the field of information technology (IT). The use of AI is limited to a few large private companies.

To accelerate the growth of AI, the government of Indonesia harnessed the concept of quadruple helix collaboration – consisting of the government, industry, academia, and the community (BPPT, 2020). Various national research and innovation resources (contributions from actors involved in the quadruple helix umbrella) need to be maximised to achieve the objectives of the AI industry research and innovation mission. This can be done by forming a quadruple helix collaboration ecosystem orchestrator called Research Collaboration and AI Industry Innovation (KORI-KA). The roles of each actor and the quadruple helix synergy in KORI-KA is shown in Figure 3.7.

Figure 3.7 Concept of Quadruple Helix Synergy in Indonesian AI Roadmap



AI = artificial intelligence, KORI-KA = Kolaborasi Riset dan Inovasi Industri Kecerdasan Artifisial.

Source: BPPT (2020).

5. TARGET AND READINESS FOR DIGITAL TRANSFORMATION

The National Research Master Plan (RIRN) 2017–2045 (Presidential Decree (Perpres) No. 38/2018)[4] defines four pillars of the 2045 vision of Indonesia and states the creative and digital economy development platform as one of the indicators of sustainable economic development.

[4] Some relevant regulations include National Medium-Term Development Plan (RPJMN), 2020–2024 (Presidential Decree (Perpres) No. 18 /2020), Road Map of the Ministry of Industry (Making Indonesia 4.0), Electronic-based government system (Presidential Decree (Perpres) No. 95/2018), and One Data Indonesia (Presidential Decree (Perpres) No. 39/2019).

Table 3.10 Four pillars of RIRN

Pillar	Description
Human development and mastery of science and technology	Achieving an equitable increase in the level of education, the role of culture in development, the contribution of science and technology to development, improving the health status and quality of life of the people, and undertaking labour reform. This includes preparing capable Indonesian human resources through science, technology, engineering, and mathematics (STEM) education and innovative research higher education activities, which represents a significant investment in the development of the Indonesian people who will act as producers in the era of the digital economy.
Sustainable economic development	Improving the investment climate, achieving open and fair international trade, harnessing industry as a driver of economic growth, realising creative and digital economic development, developing Indonesia as a leading tourist destination, undertaking maritime economic development, stabilising food security and improving the welfare of farmers, strengthening water security, increasing energy security, and fulfilling environmental commitments.
Equitable development	Accelerating poverty alleviation, equal distribution of income, equitable distribution of areas, and equitable and integrated infrastructure development.
Strengthening national resilience and governance	Enhancing Indonesia's democracy towards a democracy that carries the mandate of the people, reforming the bureaucracy and institutions, strengthening the national legal system and anti-corruption, implementing a free and active foreign policy, and strengthening defence and security.

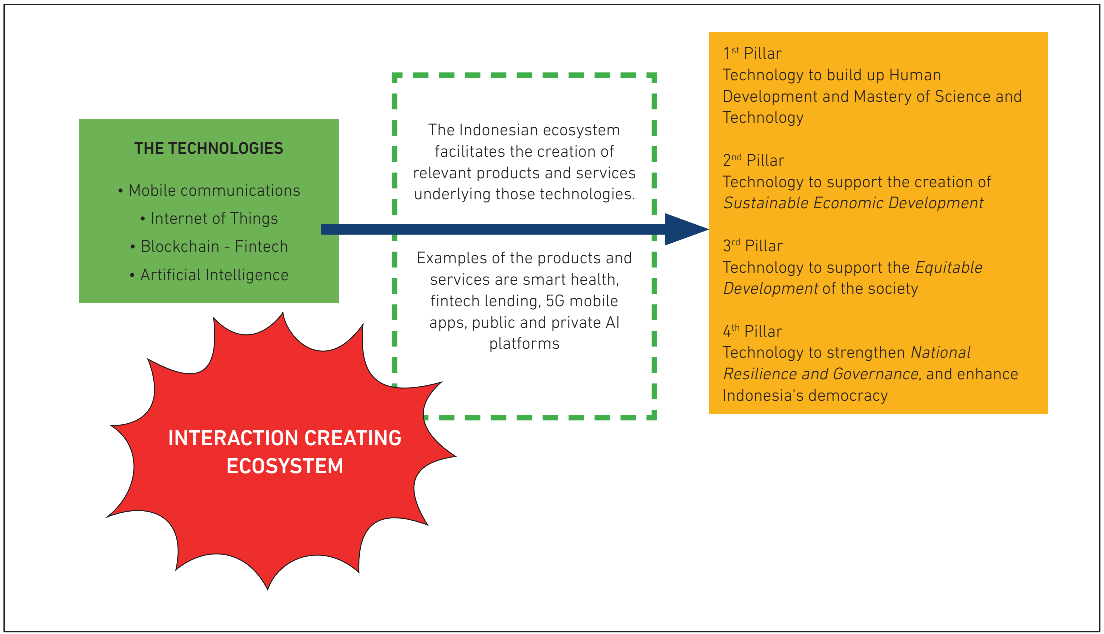
Source: RIRN, 2017-2045.

RIRN highlights the significance of science and technology in creating added value to an innovation-driven economy. Although the know-how of the technology is only an enabler of digital transformation, and in the end, the market cultivation to accommodate the applications of the new technology and the consequent new business models will be crucial to the economic and social transformation triggered by digitalisation, technology advance is fundamental.

5.1. TECHNOLOGY DEVELOPMENT APPROACH AND INTERACTION

Digital transformation requires technological areas interact with each other with focus on the main technological role. The government will take the role in coordinating interactions amongst all stakeholders of the technologies. Figure 3.8 shows how the technologies of mobile communications, IoT, blockchain, and AI play a role in achieving the four pillars of Indonesia 2045. The figure shows the first pillar, which makes science and technology an enabler of Indonesia's 2045 vision, and its relation to the economic pillar.

Figure 3.8 Digital Transformation for Achieving Indonesia's Targets in 2045

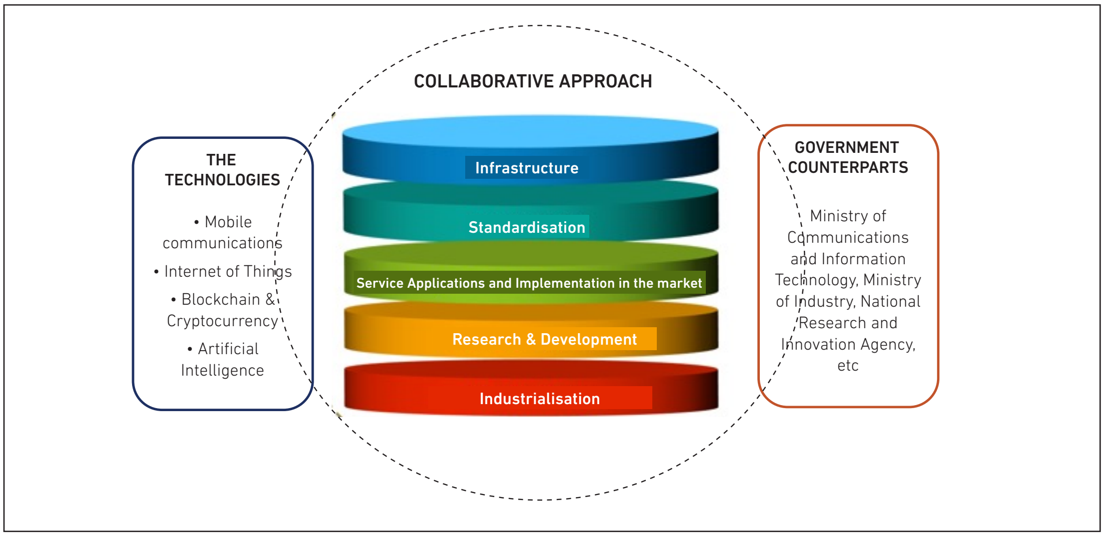


Source: Author, based on The National Research Master Plan (RIRN) 2017-2045.

Although the role of technology seems to be related only to the second pillar of the economy, the third and fourth pillars have an indicator for the achievement of the vision, whereby technology must be directed to achieve the related parameters. These include poverty alleviation, income redistribution, and even democratisation of government and national resilience. For example, the implementation of 5G should be able to facilitate the growth and development of various mobile apps that can help increase people's income, such as marketplaces. IoT has applications that help increase the quality of public health, e.g. by implementing smart health. Blockchain could help improve good governance in the financial and bureaucratic sectors. If applied to government services, blockchain could increase the security of the system so that it would have an indirect positive impact on public trust in the government.

Figure 3.9 proposes a collaborative approach that balance the approach of general development and that of area-specific development, which could help the government facilitate digital interactions across sectors.

Figure 3.9 **Collaborative Approach to Developing ICT in Indonesia**



ICT = Information and Telecommunications Technology.

Source: Author.

By analysing the functions of each of these institutions, we can take a formulation that is related to digital transformation. Such a formula requires an approach related to infrastructure, standardisation, and services applications. In terms of infrastructure and standardisation, each technology has its own characteristics, so a specific approach is needed. The Ministry of Communication and Information Technology can lead the infrastructure development, as technology is part of the ICT sector. Concerning standardisation, each technology has a specific function. For example, in relation to security standards for fintech that implements blockchain, it will involve the role of the central bank, the financial services authority, and the national body in charge of cybersecurity.

In terms of service applications, although each technology has a specific function, all of them lead to the same utilisation – supporting the vision of Indonesia 2045. Therefore, a collaborative approach is needed in the development of services and applications. Ideally, there should be very close coordination between the institutions and private parties that comprise the ecosystem. For example, IoT applications for health are a concern for four parties: (i) the Ministry of Health as the supervisor of health standards; (ii) the Ministry of Communication and Information Technology as an accelerator of the IoT network infrastructure; (iii) the National Research and Innovation Agency as a facilitator of R&D in terms of technical and technological aspects; and (iv) the Ministry of Industry, which encourages the development of domestic industry.

5.2. TOP CHALLENGES

5.2.1 Limited domestic capacity in production and R&D

The Indonesian industry of high-tech hardware is still at its early stage of development. With the country's progress in digitalisation, the market demand for digital products is fast expanding. On the supply side, however, the growth of domestic capacity lagged. A significant amount of semiconductor devices and parts and components heavily relies on imports. In 2016, the country reported a $35 billion deficit from trade in medium and high tech-insensitive products (BRIN, 2019). This highlights the importance of accelerating the catch-up process of technology adoption and increasing domestic innovation capacity.[5]

The value added of domestic R&D activities as a share of national economic output is relatively low – it contributed less than 1% of total economic growth in 2019. In Indonesia, the main source of R&D funding is still the government, which burdens over 80% of the total budget. The country's low output level looks not surprising, given its annual input in R&D is equivalent to only 0.25% of GDP, which seems an utterly inadequate measure to support domestic innovative activities.

5.2.2. Human Capital for Digital Transformation

Lack of skilled human resources is another significant challenge faced by Indonesia. According to Kemkominfo (2020), the Ministry of Communication and Information Technology projected Indonesia to have around 430,000 ICT graduates by 2020, while the national industry needs as many as 320,000 ICT workers. This suggests that Indonesia is experiencing an oversupply of ICT workers. However, the number only considers quantity while a gap (mismatch) can exist in terms of quality between industrial needs and resources from educational institutions. Such a gap can be caused by a quality mismatch gap or a field mismatch gap. One of the ways the government can solve this problem is by developing government programmes to accelerate the competence of national digital human resources – targeting 300,000 trained/certified ICT professionals by 2024.

By estimation, Indonesia will need 9 million skilled workers for digital and digital-related sectors over the next 15 years (2020–2035).[6] Even though most Indonesian universities now offer program of computer science, the profile of university graduates could not well match the demands from the industry. In Indonesia, the university curriculum only gets updated every 4 years – much slower than that of technological advance. In addition, the IT instructor who educates the candidate of skilled workers must also periodically improve their competence.

[5] Based on the 2021 Global Innovation Index, Indonesia was ranked 87th out of 132 countries.

[6] https://edukasi.kompas.com/read/2021/09/01/133356071/kemendikbud-ristek-indonesia-butuh-9-juta-talenta-digital-hingga-2035?page=all

As part of the policy response to the current situation, the Ministry of Education and Culture has launched the *Merdeka Belajar* (Freedom to Learn) programme to promote the development of human capital. In the concept of independent learning, every university student in Indonesia has the right to carry out activities for two semesters (out of eight semesters) outside the field of study in which they are engaged. Facilitated activities include taking certifications and training in IT, and internships in the industrial world. The purpose of this programme is for Indonesian university graduates to obtain competencies that meet the needs from the fast-moving industry. It also tries to bring together the university's formal education curriculum, which has been considered very rigid, with a certification curriculum that is proven to be more suitable and in line with the times.

6. POLICY RECOMMENDATIONS

From the perspective of technological progress, digitalisation should be seen as a national transformation process developed collaboratively and driven by the development of infrastructure and that of the service ecosystem. Insights from the country's selected technology profiles reveal some priorities of development that are worthy of consideration. First, promoting the infrastructure of mobile broadband technology. Indonesia already has very high mobile penetration (more than 132%). Mobile phones have become most users' preferred tool to access the internet. Improving digital connectivity is a top priority in enabling digital transformation. The increasing demand for data capacity can fuel the development and application of new network technologies, such as 5G.

Second, focusing on the development of IoT and AI technology and the promotion of localised innovation-oriented service applications. Developing IoT and AI technology requires Indonesia to steadily build up its capacity in production and innovation. Localising applications and services to match the local problems and needs of the Indonesian people could be a good starting point. IoT technology can focus on local tastes, implemented in national industries. For example, Indonesia, which is rich in palm oil, could develop IoT applications for this sector. National start-ups have developed local applications, e.g. for e-fishery, using various IoT intelligence devices that are beneficial for Indonesian fisheries and the marine industry.

Third, prioritising the implementation of AI and blockchain for financial services. The financial sector drives blockchain technology in Indonesia, although it can also be used for various projects in the telecommunications industry, environmental surveillance, transportation, banking, foreign exchange, agriculture, and even government. The growth of fintech services in Indonesia could be used as a means of seeding blockchain and AI technology, as the technology increases public trust in digital financial applications. This would be beneficial for the government because trust is needed to build effective governance in the digital economy. SMEs could be the initial target for implementation, harnessing their vast quantity and scope to contribute directly to improving people's daily activities. If such a programme were successful, SMEs could spearhead the digital transformation process in shaping the digital economy.

Fourth, to accelerate technology adoption and innovation, the government can take the driving seat, but it needs collaboration from the private sector. The technologies that contribute to the digital transformation cannot stand alone. A collaborative approach is highly recommended to ensure the achievement of the Indonesia 2045 goals. The government will not only be responsible for setting regulation and standardisation of technology, but also act as the guarantor of social welfare that promotes the equitable diffusion of technology and increases quality of life.

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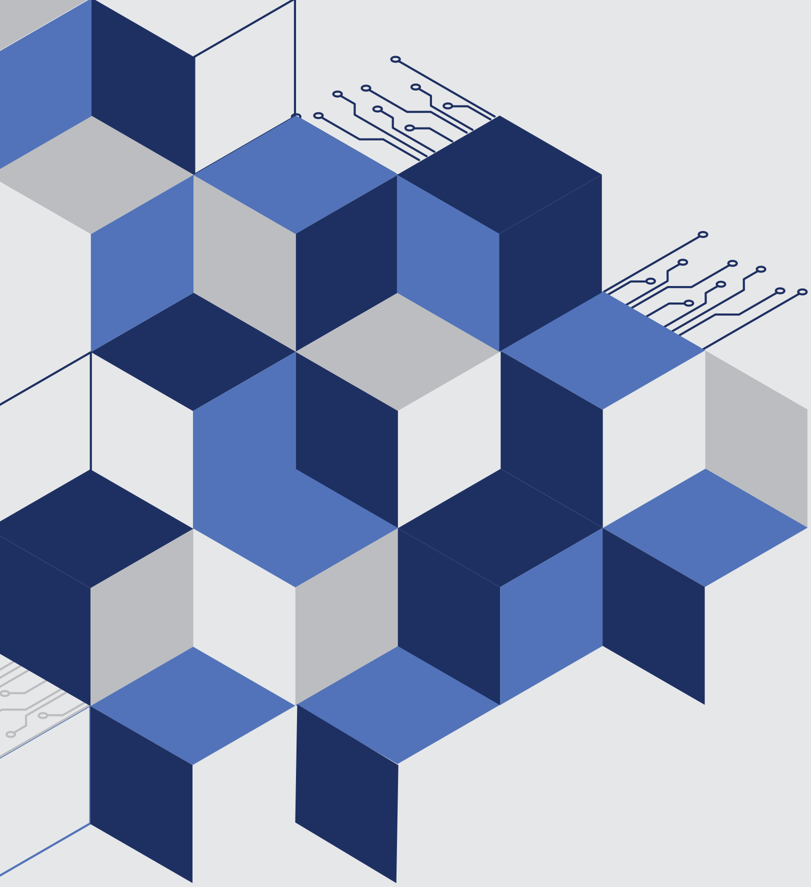


CHAPTER 4

ECONOMIC CONSEQUENCES OF DIGITAL TRANSFORMATION

Fithra Faisal Hastiadi
Askar Muhammad
Jordan Brahmansyah

1. BACKGROUND

1.1. DISRUPTIVE INNOVATIONS

At the advent of the internet in the 1990s, Harvard Business School Professor Clayton Christensen foresaw the possibilities for market disruption caused by new technologies. In 1995, Christensen made a speech on technology and innovation that evolved into his theory on 'disruptive innovation' (Bower and Christensen, 1995). This term is used to describe products and services that make use of new technologies and business models. These innovations disrupt the market by creating new demands and new types of consumers. Eventually, these innovations will replace products and services from established business players. In 2013, Christensen observed the collapse of 'sustaining' companies: those that do not innovate using new technologies, but only improve their existing services. Examples of these sustaining firms are companies that produce giant mainframe computers and those that manage fixed line telephony. These companies charge the highest prices to their most demanding and sophisticated customers to achieve the greatest profits.

According to Christensen, these great firms are collapsing since they are reluctant to open the door towards 'disruptive innovations'. Disruptive innovation allows a new population of consumers to access products or services that were historically only accessible to rich consumers. The term 'disruptive innovation' is rooted in the 'creative destruction' theory of economist Joseph Schumpeter, which describes a 'process of industrial mutation...that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one' (Schumpeter, 1942: 83).

1.2. MAKING THE BEST OF TECHNOLOGICAL DISRUPTIONS

Indonesia's task in the coming years is to find a way to elegantly monetise this wave of disruptive technologies. Trisetyarso and Hastiadi (2016) found that the wave of disruptive technology has significantly contributed to recent world economic growth. Our findings suggest that disruptive innovations will create significant capital accumulation, which is more than enough to accelerate global economic growth in the long run. Disruptive innovation follows evolution theory – the fittest survive. The capital, knowledge, and labour of disruptive innovation will remain, while the capital, knowledge, and labour in mainstream technology will not.

Governments should catch the wave of technological disruption. Regulation plays an essential role in harnessing disruptive innovations. This chapter tries to address the dynamics of such regulation, along with tapping the tangible value of the intangible digital sectors in the Indonesian economy.

Imposing taxes or tariffs/duties on intangible digital products (IDPs) is one of the most discussed topics in today's economic policy debates. With the broad classification of IDPs, proponents have stated that imposing IDP tariffs/duties will generate revenue for the government and give fair treatment for both tangible (material) and intangible products. The idea of implementing a tariff/duty on electronically transmitted/digital products is controversial as IDPs can also be considered services and it is difficult to pinpoint the boundary between their 'goods' and 'services' aspects.

Members of the World Trade Organization agreed not to impose import duties on electronically transmitted products through a moratorium that has been in place since 1998. However, several countries have voiced their intention to end the moratorium and impose such a tariff/duty – including Indonesia. Chapter 99 of the Ministry of Finance Regulation No. 17/PMK.010/2018 sets a 0% rate duty on digital goods, which are defined as 'operating system software, application software, multimedia audio visual, supporting driver data for machinery system, and other software and digital goods'.

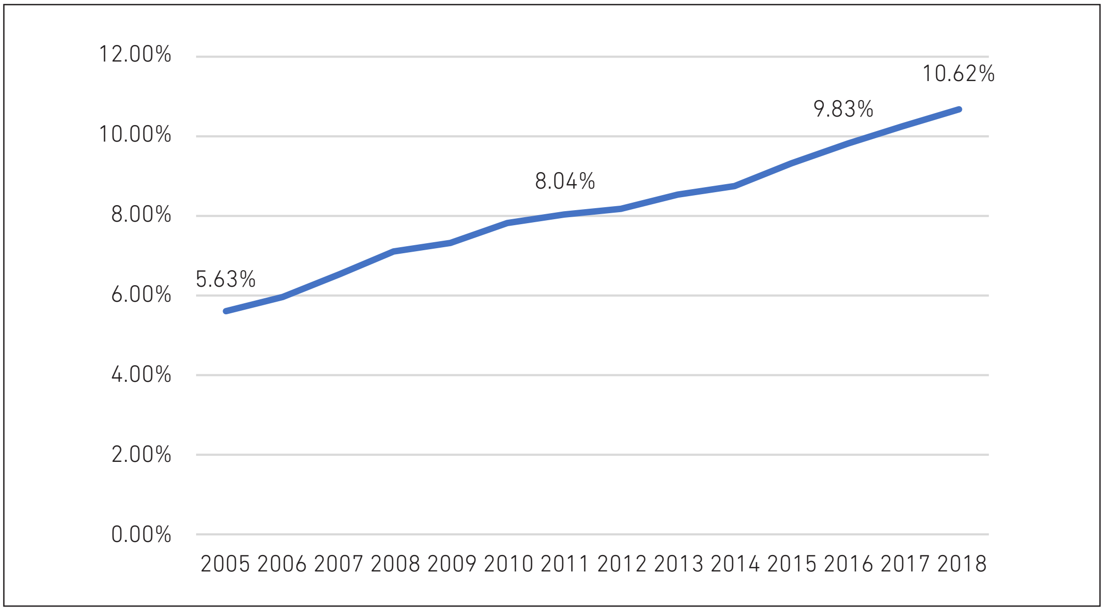
This chapter explores the potential economic contributions of the intangible digital product sectors – along with the possibility of retaliations from trade partners if we impose tariffs on the particular sector It is divided into five sections: section 1 provides a literature review of the digital economy, section 2 explains the method of analysis, section 3 describes the sectoral interlinkages along with the potential loss if retaliatory actions are taken by other countries, and section 4 concludes.

2. LITERATURE REVIEW

2.1. AN APPROACH TO ESTIMATING THE DIGITAL ECONOMY

Studies by McKinsey & Company projected the transaction value of the digital economy to reach $150 billion, equivalent to 10% of Indonesia's gross domestic product (GDP), if Indonesia is digitalised by 2025 (Das et al., 2016). However, the measurement of the digital economy presents some challenges since it is difficult to identify whether many items that are traded on the internet include goods or services (Moulton, 2000). Some of them are even free of charge. The quality of the economic data is very important to develop the economy, particularly in today's fast-changing environment. For instance, releases of GDP statistics, which are often monitored by policymakers and financial analysts, are useful for analysing the economic situation. Economic statistics play an important role in public policy decisions (Barbet and Coutinet, 2001).

Figure 4.1 Contribution of the Digital Economy to US GDP, 2005–2018



GDP = gross domestic product, US = United States.

Source: Authors' illustration, based on United States Bureau of Economic Analysis Database (2020).

As depicted in Figure 4.1, the contribution of the digital economy to GDP in the United States (US) rose steadily from 5.63% in 2005 to 10.62% in 2018. Conceptually, a digital economy account must include all goods and services related to the digital economy. Yet, what is presented in the figure is still based on goods and services in the digital economy in general. The figure is unable to separate items that are, for example, 'partially digital'. This means that some components of the digital economy, such as peer-to-peer (P2P) e-commerce, are not included in the US Bureau of Economic Analysis calculations. In the figure, the goods or services that are taken into account include hardware, software, telecommunications, e-commerce, and digital media. However, the contribution of software remained relatively small, at 1.34%, in 2016.

According to Haltiwanger and Jarmin (1999), to measure the digital economy, data are required to measure investment in physical infrastructure (e.g. information technology (IT) equipment including computers, telephone lines, switches, fibre optic cables, satellites, wireless networks, and local area network (LAN) equipment); investment in software infrastructure; other internet capacity in communication networks; actual traffic on information systems; and depreciation in infrastructure (IT equipment, software, or hardware).

In their efforts to calculate the contribution of the digital economy to the overall economy, Barbet and Coutinet (2001) noted several approaches, including:

(i) Organisation for Economic Co-operation and Development (OECD) Approach
   (a) Working Party on Indicators for the Information Society
   In 1997, this approach classified the digital economy into three sectors: the computer hardware manufacturing industry; telecommunications hardware and services, and software; and information (content) activities (press, editing, television shows, etc.) (Working Party on Indicators for the Information Society, 2002).
   (b) OECD
   In 2000, the OECD complemented the previous indicators by defining digital economic products in goods/manufacturing and services. Digital economy goods/manufacturing products are goods that are intended to fulfil information processing and communication functions, including electronic transmission and display. Meanwhile, digital economic service products are services that are intended to enable information and communication processing functions by electronic means. Contingent upon the International Standard Industrial Classification of All Economic Activities (ISIC), the OECD classification covers the following goods: accounting and office computing machines; insulated wires and cables; electronic valves and tubes and other electronic components; transmitters and television and radio equipment for telephone lines and telegraphic channels;

television receivers and radios; sound or video recording or reproduction devices; and related goods, instruments, and equipment for measuring, examining, testing, and navigating, as well as equipment for controlling industrial processes. The services include wholesale sales of machinery, equipment, and information and communication technology (ICT) supplies; rental of machinery and office equipment (including computers); telecommunications services; and services related to computer activities (OECD, 2000).

(ii) US Approach

(a) US Department of Commerce Approach

The digital economy is defined as economic activity that is very closely related to digital activity. For this reason, in this approach, economic activities that are considered closely related to digital activities are the hardware industry, the software industry and services, and the communications equipment and service industry. The hardware industry is a supplying industry that provides (both through wholesale and retail sales) computers and equipment, office machines, and other electronic equipment for measurement. The software industry and services are industries and services that provide pre-packaged software and computer-related services. The communications equipment and service industry is a supplying industry that provides material and non-material 'infrastructure' that enables connections between computers and servers that become the basis of internet development and electronic commerce (U.S. Department of Commerce, 2000).

(b) North American Industry Classification System Approach

This approach focuses on industries that provide ICT-based information rather than industries that provide ICT hardware. This sector consists of companies that produce and distribute information, provide means to transmit or distribute data/communication services, and data processing. For example, it comprises the software publishing industry, internet publishing and broadcasting, internet service providers, web search portals, and data processing services (Executive Office of The President of The United States, 2002).

(c) US Census Bureau Approach to Electronic Economics

The electronic economy entails electronic business, electronic commerce, and electronic business infrastructure. Electronic business is any process carried out by business organisations (including non-profits and governments) through computer-mediated network channels. Electronic commerce, on the other hand, is any transaction completed through a computer-mediated network that transfers ownership of, or the right to use, goods or services. Finally, electronic business infrastructure is economic infrastructure that is used to support electronic business processes and conduct electronic trade transactions (Atrostic, Gates, & Jarmin, 2000).

(iii) European Approach

(a) Eurostat Approach

This approach considers the fact that an increase in the volume of ICT-related goods and services is produced outside the traditionally established ICT industry. It arises from the emergence of the concept of 'embedded intangibility' because of the increasingly vague boundaries between tangible and intangible goods, goods and services, visible and invisible trade, knowledge-based work, etc. (Eurostat, 2000).

2.2. RETALIATION POTENTIAL FROM TAXING THE DIGITAL ECONOMY

One of the discussions that has become a concern lately is taxing the digital economy. This issue attracts quite a lot of attention, not only in Indonesia, but also throughout the world, such as in the European Union (Lee-Makiyama, 2018). Taxation of the digital economy is an important issue for reasons of justice – equality of tax treatment for the conventional economy and the digital economy – and to fulfil the roadmap stipulated in Presidential Regulation No. 74 of 2017 (Solikin, 2017).

Nevertheless, as Lee-Makiyama (2018) argued, taxing the digital economy could harm a country's economy instead of increasing tax revenue. One potential disadvantage is retaliation – actions taken by countries whose exports are adversely affected by tariff increases or other trade-restrictive measures taken by other countries. This is possible if several companies engaging in the digital economy are foreign companies that export their services or goods to Indonesia or establish their companies in Indonesia. Retaliation occurs when an importing country, say country A, sets tariffs for all or many of their imported goods, so that internationally it will reduce the national welfare of its trading partners, say country B. If country B wishes to maintain its own national welfare, it is likely to set tariffs on goods imported from country A. One effective way to reduce losses in national welfare is to respond with tariffs on imported goods. Retaliation also has the potential to create trade wars.

To avoid retaliation from trading partners, Indonesia must continue to adhere to the international system. It cannot impose taxes or tariffs arbitrarily without involving trade partners in negotiations. The imposition of taxes or tariffs must be discussed during trade negotiations. If negotiations are not carried out, the potential for retaliation and trade wars will rise. Retaliation will adversely affect Indonesia. International negotiations can help avoid trade wars (Krugman, Obstfeld, and Melitz, 2012).

To assess the adverse effects of taxation or tariffs, we must identify the extent of Indonesia's exports or direct investments to partner countries which would tax the goods. For example, if Indonesia imposes a digital economy tax on country X, we must look at the size of Indonesia's exports and direct investment related to the digital economy to country X. The greater the export and direct investment, the greater the potential loss that Indonesia would experience. Instead of obtaining a fiscal advantage over the taxation, Indonesia would suffer a fiscal loss. This framework, issued by Lee-Makiyama (2018), attempted to assess fiscal losses if the European Union were to impose a digital services tax.

3. RESEARCH METHODS

This part uses the input–output (IO) method to analyse the linkages between sectors and key sectors and multiplier analysis. It conducts analysis of inter-sectoral linkages and key sectors to see which sectors have strong links with other sectors, both upstream and downstream, and to identify which sectors are key. Meanwhile, multiplier analysis is performed to see which sectors have high multipliers in output, household income, and value added.

3.1. ANALYSIS OF LINKAGES BETWEEN SECTORS AND IDENTIFICATION OF KEY SECTORS

Linkage index analysis is applied to look at inter-sectoral linkages, which can be seen as backward and forward linkages. Backward linkage refers to linkage with the raw material and is calculated according to the column in the IO table, while forward linkage refers to the sales of finished goods and is calculated according to the rows in the IO table.

Within the framework of the IO model, production by certain sectors has two types of economic impacts on other sectors of the economy – backward and forward. If sector 1 experiences an increase in output as a result of increased demand, sector 1 will need more inputs to produce its output so that sectors that become suppliers (upstream sector) to sector 1 will feel the effects of increased output in sector 1. A sector that has strong linkages with the input providers has a strong backward linkage. On the other hand, an increase in output in sector 1 means that an additional amount of product from sector 1 is available to be used as input to other sectors for their own production because there will be an increase in supply from sector 1 (as a seller) for sectors that use the output of sector 1 in their production. A sector that has strong links with the sectors that use its output as input goods is a sector that has strong forward links. The term backward linkage is used to indicate the type of interconnection of a particular sector with the sectors (upstream) from which it purchases inputs. Meanwhile, the term forward linkage is used to indicate this kind of interconnection from a particular sector with the sectors (downstream) where it sells its production.

A comparison of the strength of backward and forward linkages for sectors in an economy provides a single mechanism for identifying key or leading sectors in the economy. Consequently, economic policymakers can identify which sectors should be considered. If the backward or forward linkage from sector *A* is greater than that of sector *B*, an expansion value of Rp1 from sector *A* output will be more beneficial to the economy than the same expansion in sector *B* output.

3.2. MULTIPLIER ANALYSIS

The inter-sectoral linkage analysis technique does not show a series of effects from one sector to another sector in an economy. Therefore, a multiplier analysis needs to be performed to trace the series of effects of a sector on the economy as a whole. Basically, a multiplier is a measure of the response to the stimulus of change in an economy, expressed in a causal relationship. The multiplier in the IO model is assumed as a response to the increasing demand for a sector.

In general, a multiplier analysis is an analysis used to track the impact of exogenous changes on the economy. The type of multiplier for which impacts are most often seen is (i) the output of sectors in the economy, (ii) income earned by households in each sector due to new output, (iii) the number of jobs generated in each sector due to new output, and (iv) value added created by each sector in the economy due to new output. In this study, the type of multiplier is limited to output, household income, and value added. The number of jobs is not taken into account due to data limitations.

4. RESULTS AND DISCUSSION

4.1.CONTRIBUTION OF THE DIGITAL ECONOMY TO THE OVERALL ECONOMY

4.1.1. Relationship Analysis Between Sectors

Based on the IO processing results, the backward and forward linkage index of each sector is formed. From these results, the researcher identifies which sectors can be classified as key sectors. Key sectors are sectors that possess strong backward and forward linkages. In this case, both indices – the Index of Total Forward Linkage (ITFL) and the Index of Total Backward Linkage (ITBL) – must have values exceeding 1. Our calculation successfully identifies nine key sectors, as depicted in Table 4.1.

Table 4.1 Key Sectors

No.	Sector
1	Machinery and equipment industry
2	Chemical, pharmaceutical, and traditional medicine Industry
3	Coal and oil and gas refinery industry
4	Food and beverages industry
5	Electricity and gas procurement
6	Metal goods industry; computers, electronics, and optics; and electrical equipment
7	Paper and paper products industry; printing and reproduction of recording media
8	Craft
9	Basic metal industry

Source: Authors' compilation.

Table 4.1 lists the key sectors, which have great potential for driving other sectors. The increase in demand in these sectors has the potential to lift output in other sectors, on both the upstream and downstream sides. Nonetheless, if we recall the main topic of this research – IDPs – not many key sectors are related to IDPs. Table 4.2 demonstrates the results of the analysis of inter-sectoral linkages in sectors that have linkages to IDPs.

Of the 14 sectors identified to have a strong relation to IDPs (Table 4.2.), only two sectors are classified key sectors: (i) metal goods; computers, electronics, and optics; and electrical equipment; and (ii) craft. The information and communication sector, though not identified as a key sector, has strong backward linkages.

Table 4.2 Analysis Results of Inter-Sectoral Linkages in Sectors Related to IDPs

No.	Sector	ITBL	ITFL	Key sector
1	Metal goods; computers, electronics, and optics; and electrical equipment industry	✔	✔	✔
2	Craft	✔	✔	✔
3	Information and communication	✔	-	-
4	Photography	-	-	-
5	Application and game developer	-	-	-
6	Television and radio	-	-	-
7	Advertising	-	-	-
8	Product design	-	-	-
9	Interior design	-	-	-
10	Performing arts	-	-	-
11	Visual communication design	-	-	-
12	Fine Arts	-	-	-
13	Music	-	-	-
14	Film and animation and video	-	-	-

ITBL = Index of Total Backward Linkage, ITFL = Index of Total Forward Linkage.

Source: Authors' compilation.

Overall, the sectors that are related to IDPs do not have strong linkages with inter-sectoral supply chains. The increase in demand for these sectors does not have adequately strong linkages to increase output in other sectors of the economy. Weak linkages between sectors are generally caused by sector productivity, institutional relationships and frameworks, supply chain health, production structures, spatial linkages, types of goods produced, complexity of the goods production process, and the amount of raw material needed to produce an item (Miller and Blair, 2009; Subramaniam and Reed, 2009).

The weak inter-sectoral linkages in the sectors that have linkages to IDPs may occur due to the production structure of IDPs, which do not require a lot of raw materials to produce since they tend to be created from intellectual property (Karius, 2016). Intellectual property may not be supplied from other sectors, so the intangible goods sector does not have a sufficiently strong relationship with the upstream sector. Based on the researcher's calculations, on average, the IDP sector produces 48.49% of its own input. This implies that almost half of the input is obtained from the sector itself and is not purchased from other sectors. On the other hand, IDPs are generally final goods, not intermediate goods, so they cannot be used as inputs for other sectors. Based on the researchers' calculations, on average, the IDP sector only contributes 6.65% of the total inputs needed by other economic sectors. This is different from the metal goods industry sector; computers, electronics, and optics; and electrical equipment; and craft sector, whose products can also play a role as semi-finished goods. To this point, it can be concluded that the nature of the IDPs causes these sectors not to have strong backward and forward linkages.

4.1.2. Multiplier Analysis

Table 4.3 shows that only two sectors are related to IDPs (4 and 6), which are included in the 10 sectors with the highest output multiplier. This denotes that the sectors that have linkages to IDPs are not sectors that can provide major boosts to economic output.

Table 4.3 Ten Sectors with the Highest Output Multiplier Figures

No.	Sector	Output multiplier
1	Machinery and equipment industry	3.193
2	Electricity and gas procurement	3.160
3	Metal goods; computers, electronics, optics; and electrical equipment industry	2.758
4	Paper and paper products industry; printing and reproduction of recording media	2.622
5	Air transportation	2.393
6	Craft	2.387
7	Sea transportation	2.358
8	Construction	2.354
9	Basic metal industry	2.313
10	Other processing industries; repair and installation services of machinery and equipment	2.293

Source: Authors' compilation.

Table 4.4 presents the 10 sectors with the highest income multipliers. It is evident that there is a unique sector (intangible) amongst the other sectors, i.e. music.

Table 4.4 Ten Sectors with the Highest Income Multiplier

No.	Sector	Income multiplier
1	Educational services	0.663
2	Government administration, defence, and mandatory social security	0.646
3	Other services	0.473
4	Health services and social activities	0.390
5	Machinery and equipment industry	0.372
6	River and lake river transportation	0.367
7	Music	0.356
8	Mining and other excavations	0.351
9	Leather industry, leather goods, and footwear	0.348
10	Government administration, defence, and mandatory social security	0.336

Source: Authors' compilation.

Table 4.5 shows the 10 sectors with the highest value-added multiplier. Six of the 10 sectors are related to IDPs. This means that IDP-related sectors are those that can provide a significant increase in the economic value added. Value added is defined as the difference in value between an industry's output (consisting of sales or revenue and other operating income, commodity taxes, and inventory changes) and intermediate input costs (including energy, raw materials, semi-finished goods, and services purchased from all sources). Value added describes what happens when a commercial company processes a product by increasing its value (and its price) and by adding extra processes to its manufacturing phase or by providing additional services. IDP sectors produce goods with high value added.

Table 4.5 Ten Sectors with the Highest Value-Added Multiplier

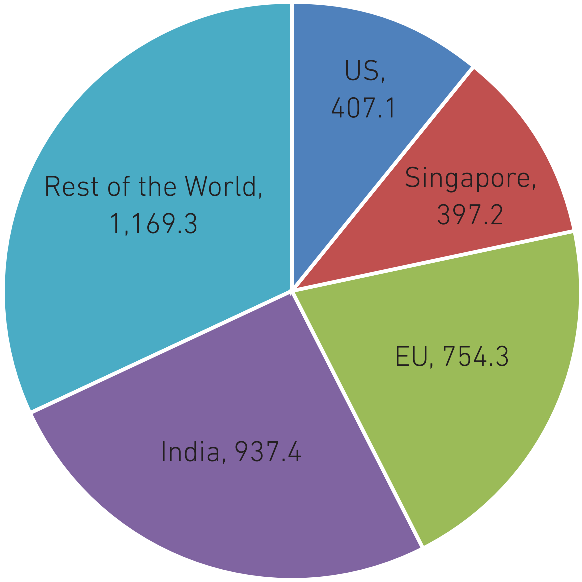
No.	Sector	Value-added multiplier
1	Music	1.008
2	Publishing	1.004
3	Advertising	1.004
4	Fashion	1.002
5	Application and game developer	1.001
6	Film and animation and video	1.000
7	Educational services	1.000
8	Performing arts	1.000
9	Financial intermediary services	1.000
10	Visual communication design	1.000

Source: Authors' compilation.

4.2. POTENTIAL FOR IMPACT OF RETALIATION FROM DIGITAL ECONOMY TAXATION

The study employed the analytical framework used by Lee-Makiyama (2018) to explore the potential impacts, particularly on fiscal retaliation, which would occur if a digital economy tax were applied. However, there is lack of data related to digital services in Indonesia. This is therefore proxied by the export and import data of the information and communication sectors (D58T63: Information and communication) taken from the OECD Trade in Value Added (TiVA) database. We also applied several scenarios for tax rates (i.e. 3%, 5%, and 10%) to proxy the tax rate for the digital economy. Figure 4.2 displays the volume of imports of Indonesia's information and communication by country of origin. The chart indicates that almost 25.57% of Indonesia's information and communication imports are from India. Together with the European Union (EU) and the US, the three countries have a cumulative share of around 57.26% of Indonesia's information and communication imports. In 2015, Indonesia's global information and communication imports reached $3.6 billion, of which $2.1 billion were from India, the EU, and the US.

Figure 4.2 Indonesia's Information and Communication Imports by Country of Origin, 2015 ($ million)



EU = European Union, US = United States.

Note: EU-28 refers to the 27 EU member states plus the UK.

Source: Authors' illustration based on OECD TiVA Database (2021).

At present, according to the Regulation of Minister of Finance (Peraturan Menteri Keuangan/PMK) No. 6 of 2017, machinery and electronics are subject to tariffs, which vary from 0% to 15%, reinforcing our chosen scenario of 3%, 5%, and 10%. By imposing tariff rates of 3%, 5%, or 10%, our simulation shows that the government will obtain a fairly high tax revenue, as depicted in Table 4.6.

Table 4.6 Potential Tax Revenues from Information and Communication Imports

Source of revenue ($ million)	Scenario		
	3%	5%	10%
Potential revenue from India	28.12	46.87	93.74
Potential revenue from EU-28	22.63	37.72	75.43
Potential revenue from US	12.21	20.36	40.71
Potential revenue from all over the world	109.96	183.27	366.53

Source of revenue (Rp trillion)*	Scenario		
	3%	5%	10%
Potential revenue from India	0.40	0.67	1.34
Potential revenue from EU-28	0.32	0.54	1.07
Potential revenue from US	0.17	0.29	0.58
Potential revenue from all over the world	1.57	2.61	5.22

EU = European Union, US = United States.

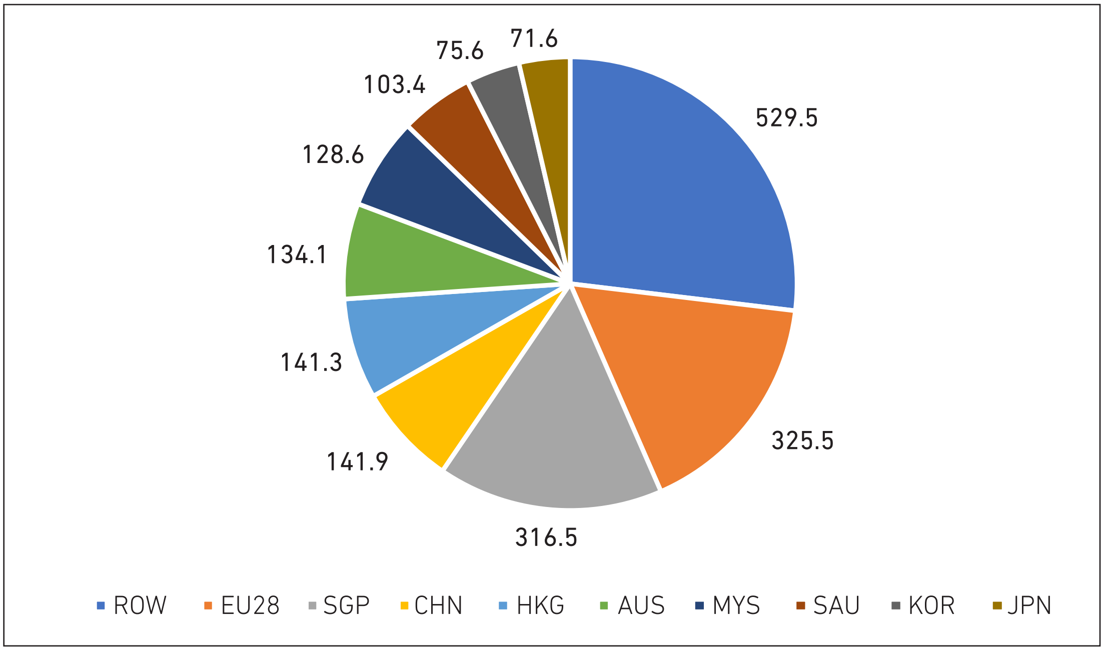
Note: EU-28 refers to the 27 EU member states plus the UK.

* Assumed rate: $1 = Rp14,247.20.

Source: Authors' calculations.

Based on Table 4.6, we can see that the potential tax revenue from imposing an additional tariff of 3%–10% will at least generate Rp1.57 trillion for the government. Nonetheless, setting a tariff has the potential of creating another problem – potential retaliation from trading partners. To make this clear, we need to know the size of our exports.

Figure 4.3 Indonesia's Information and Communication Exports by Country of Destination, 2015 ($ million)



AUS = Australia, CHN = China, EU = European Union, HKG = Hong Kong, JPN = Japan, KOR = Republic of Korea, MYS = Malaysia, ROW = rest of the world, SAU = Saudi Arabia, SGP = Singapore.

Note: EU-28 refers to the 27 EU member states plus the UK.

Source: Authors' illustration based on OECD TiVA Database (2021).

Unlike imports, Indonesia's main trading partners in information and communication exports are diverse. If imports from the three countries dominate half of the total imports, in the context of exports, at least a combination of five trading partners – the EU-28, Singapore, China, Hong Kong, and Australia – are needed to achieve the same level of dominance. In total, Indonesia's exports from the information and communication sector are small in comparison to its imports. Indonesia's imports from the information and communication sector are almost twice its exports. From this figure, we may at least expect that the potential loss may not be as large as the potential revenue received, if retaliation occurs.

Table 4.7 reveals the potential tax to be paid if trading partners retaliate. If we compare this with the potential tax revenue that will be gained, the potential for tax payments will not generate a significant amount. The potential for tax payments is always smaller than the potential for tax revenue. On average, the potential for tax payments is only equivalent to 53.7% of the potential tax revenue. But this not the end of the story – tax retaliation on digital goods might go beyond what we have seen here.

Table 4.7 Potential Tax Payments (Retaliation Effect) from Information and Communication Exports

Spending ($ billion)	Scenario		
	3%	5%	10%
Potential tax payments to EU-28	9.77	16.28	32.55
Potential tax payments to Singapore	9.50	15.83	31.65
Potential tax payments to China	4.26	7.10	14.19
Potential tax payments to Hong Kong	4.24	7.07	14.13
Potential tax payments to Australia	4.02	6.71	13.41
Potential tax payments to all over the world	59.04	98.40	196.80

Spending (Rp trillion)*	Scenario		
	3%	5%	10%
Potential tax payments to EU-28	0.14	0.23	0.46
Potential tax payments to Singapore	0.14	0.23	0.45
Potential tax payments to China	0.06	0.10	0.20
Potential tax payments to Hong Kong	0.06	0.10	0.20
Potential tax payments to Australia	0.06	0.10	0.19
Potential tax payments to all over the world	0.84	1.40	2.80

EU = European Union, US = United States.

Note: EU-28 refers to the 27 EU member states plus the UK.

* Assumed rate: $1 = Rp14,247.20.

Source: Authors' calculations.

A tariff rate of 3%-10% would generate at least Rp1.57 trillion in potential fiscal revenue for the government. Yet, setting a tariff could cause retaliation from Indonesia's trading partners on a wide range of goods. Table 4.8 summarises three possible scenarios. The first scenario does not cause a severe impact to Indonesia's fiscal revenue. In fact, even though the trade partners retaliate, Indonesia still receives more revenue than it loses, as we saw in Table 4.7. Nonetheless, the other two scenarios may incur more revenue loss than revenue received. Unfortunately, the second and third scenarios will be the most likely actions from the trade partners – covering more than just the information and communication sector. With this in mind, the fiscal side will also face some negative effects.

Aside from the fiscal effects, there are other impacts on the quantity of goods imported. The decline in imported goods would be a problem if the imported goods were semi-finished or raw, so that they could be used as input for the domestic industry. When the government decides to raise tariffs, prices will become more expensive, so the input goods that will be used by domestic industries to process outputs become more expensive. In the end, the input used will be cut off to control the total cost of production.

Table 4.8 Potential for Impact of Retaliation from Digital Economy Taxation
(Rp trillion)

Tariff rate	Potential fiscal revenues	Potential fiscal losses*	Potential fiscal losses**	Potential fiscal losses***	Differ-ence*	Differ-ence**	Differ-ence***
3%	1.57	0.84	4.97	23.64	0.73	-3.40	-22.07
5%	2.61	1.40	8.28	39.40	1.21	-5.67	-36.79
10%	5.22	2.80	16.56	78.80	2.42	-11.34	-73.58

EU = European Union.

Note: EU-28 refers to the 27 EU member states plus the UK.

* The scenario where the trading partners set tariffs only on information and communication exports.

** The scenario where the EU-28, Singapore, China, Hong Kong, and Australia set tariffs only on the type of goods/services with the largest export value.

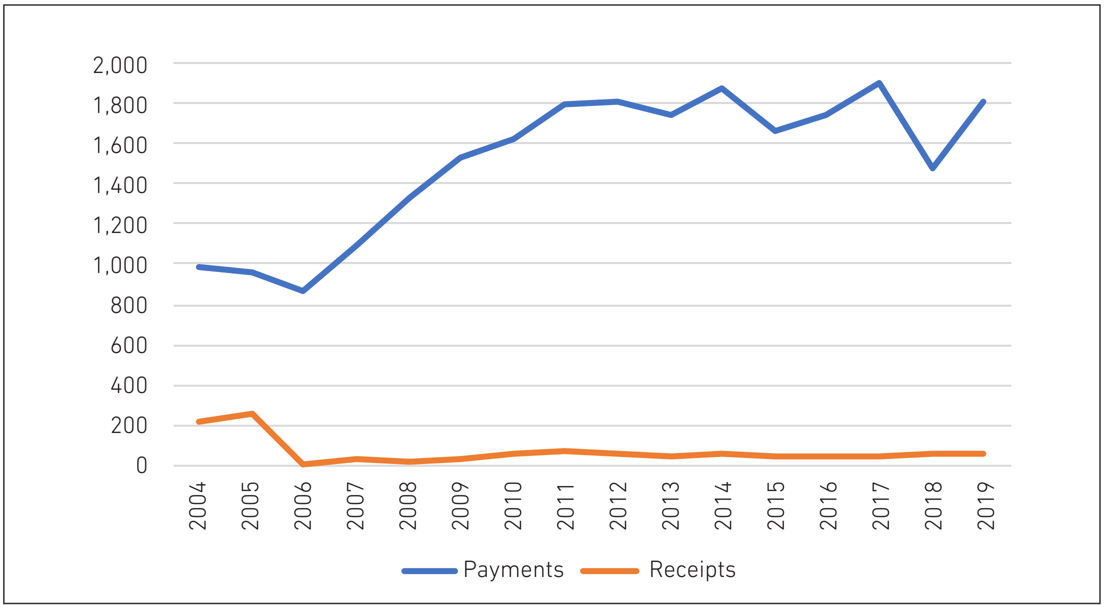
*** The scenario where the EU-28, Singapore, China, Hong Kong, and Australia set tariffs on all Indonesian exports, regardless of the type of goods/services.

Source: Authors' calculations.

Figure 4.4 illustrates the high amount paid by Indonesia to use intellectual property rights. This implies that many goods that are protected by intellectual property rights are used in Indonesia – for household consumption or as inputs in the production process.

Raising tariffs could hurt domestic industry as it would increase the price of production inputs, considering that 33% of Indonesia's imports are semi-finished goods. The results show that a tariff increase of 3%–10% would reduce domestic output by Rp17.2 trillion or up to Rp57.3 trillion, which is equivalent to an output decrease of 0.09%–0.29%. Although there is a difference in tax revenue of Rp14.74 trillion–Rp49.13 trillion, an output decrease that is greater than that difference needs to be taken into consideration. Moreover, the trading partners could retaliate in other sectors that are not related to the sectors of concern.

Figure 4.4 **Indonesian Charges for the Use of Intellectual Property, 2004–2019**
(balance of payments, current $ million)



Source: Authors' illustration based on World Bank's World Development Indicator Database (2021).

Several studies have argued that tariff hikes, through potential retaliation, would damage economic welfare and cause net losses in production and employment as well lower income levels. York, Pomerelau, and dan Bellafiore (2019) predicted that the tariff increases under US President Donald Trump would reduce economic growth by 0.74%, decrease income by 0.48%, and increase unemployment by 570,591 people. A study of the US–China trade war found that trade conflicts have sporadic impacts on various countries in the world. The same study also found that China's GDP would fall by more than 1% and US GDP would drop by 0.2% over a 2- to 3-year period. Meanwhile, developing countries in Asia experience a rather positive impact because the region has benefited from the diversion of trade in electronics and textiles. The inclusion of car tariffs and auto parts is more damaging for developed countries (e.g. the EU and Japan) than for developing Asian countries. Furthermore, a large negative effect on employment in China and the US takes the form of a rise in unemployment of 8.6 million people (1%) in China and 329,000 people (0.2%) in the US (Abiad et al., 2018). Another study by Li, He, and Lin (2018) found that the trade war between China and the US would result in a decline of 0.541% in Chinese welfare, 2.459% in GDP, 3.858% in employment, 7.912% in trade, 12.263% in exports, and 2.653% in imports. Although the same study projected US welfare to increase by 0.041% and GDP to rise by 0.611%, employment was forecast to fall by 0.918%, exports were expected to plunge by 2.244%, and imports were predicted to stumble by 12.203%. Additionally, the study found that global welfare would decrease by 0.016%, GDP would drop by 0.264%, manufacturing production would decrease by 1.227%, employment would fall by 0.668%, and trade would decrease by 2.099%. The World Bank stated that the US–China trade war could cut global exports by 3% ($674 billion) and global income by 1.7% (41.4 trillion), with losses in all regions. Income losses range from 0.9% for South Asia to 1.7% for Europe and Central Asia (Freund et al., 2018).

5. CONCLUSION

Rapid technological development and innovation in Indonesia have created an exciting array of opportunities across stakeholders. The technology industry is increasingly working to develop software, devices, network solutions, and other tools that meet the needs of the people, with applications in everything from public safety to energy management to library operations. The opportunities presented, however, do not come without risk. Without a clear sense of direction or standards, and in the absence of a proper understanding of the sectoral interlinkages, regulation may hinder sectoral growth and could pose threats to partner countries.

Based on our analysis, taxing the intangible sectors will provide some unprecedented effects in the form of retaliation. The study also shows that IDP-related sectors, albeit having insignificant output and income multipliers, can generate high value added across sectors. Implementing such tariffs could put Indonesia in a weaker position in the international trade arena. Indonesia should not risk being subjected to retaliatory measures, especially for IDP-related products, where the domestic industry still does not have the capacity to meet the demand.

Governments should catch the wave of technological disruption. Regulation plays an essential role in harnessing disruptive innovations. However, regulation could also preclude quality-enhancing lower-cost innovations from entering the market. Flexible regulations should be there to cope with this trend.

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CHAPTER 5

POLICY RECOMMENDATIONS

Lurong Chen

Indonesia is generally in good shape to harness the digital society. The next step is to complete a digital-friendly development ecosystem to facilitate digital transformation and create opportunities to realise the potential of data-driven growth. Given the country's stage of digitalisation and economic vision, here are four policy priorities for Indonesia.

1. IMPROVING CONNECTIVITY

Digital connectivity covers both connections in the physical world and the free flow of data in cyberspace. These two 'worlds' influence each other.[1] Digital infrastructure – both hardware and software – is the key to connectivity. In addition to investment in physical infrastructure, improvement in the quality of services is directly linked to the quality of overall connectivity. Connectivity cannot function well without well-constructed infrastructure and the input of qualified services.

Chen (2020) identified five typical development gaps in information and communication technology infrastructure in many Asian countries, including Indonesia: (i) uneven network coverage, (ii) different internet connection speeds, (iii) gaps in affordability,[2] (iv) gaps in online content and services, and (v) gaps in the security and reliability of the network.

There is a risk that existing development gaps may exacerbate to a digital divide within the country. In this regard, actions to improve digital connectivity should aim at reducing the divide by increasing the supply of public goods, in both quantity and quality. This may require public sector leadership, but it is equally important to involve the private sector to sustain the development of the digital economy. Public–private collaboration will help not only in building infrastructure, but also in establishing rules and legislation that regulate the whole digital ecosystem.

[1] For instance, the performance of fibre-optic cables will determine the speed of data flow on the internet, whereas major cyberattacks may lead to chaos in the real world.

[2] Poorer people may need to spend larger percentages of their income on mobile data.

2. PRIORITISING DEVELOPMENT OF THE SMARTPHONE ECONOMY

Indonesia could and should focus on new technologies that can facilitate its digital transformation, particularly development of the smartphone economy.

A smartphone can replace many other devices and integrate their functions by simply adding applications (apps) to its memory chip. In Indonesia, technical conditions on using smartphones are maturing – both in terms of the functionality and affordability of phones, and the variety and reliability of apps to be installed. Market conditions are also favourable – having dramatically driven down both the price of devices and the cost of mobile data use. With this, smartphones and mobile apps provide a powerful platform for Indonesian users to make the most of the internet.

Policy efforts to promote the development of smartphones and mobile apps in Asian countries could come through the following channels (Kimura and Chen, 2017; Chen, 2019):

i. Emphasise the supporting infrastructure of smartphones, such as increasing wireless bandwidth and the number of internet exchange points (IXPs).
ii. Keep driving down the cost of mobile data use, of which market competition will be the main driver. Rules and regulation help prevent either monopoly or destructive competition of the market.
iii. Care about low-income people who cannot afford smartphones. The government should consider providing subsidies (or encouraging business donations) to help them obtain devices and, moreover, provide them with the necessary training on how to use the apps.
iv. Encourage creation and incremental innovation, especially customising digital services to meet the needs of Indonesian users.

3. LIBERALISING THE DIGITAL ECONOMY

In Indonesia, one big obstacle facing digitalisation may be its capacity limits in terms of capital and technology. Therefore, it is important to keep the door open and get involved in international production sharing. New technology, know-how, and modern management skills go hand in hand with foreign inward investment and global value chain participation. Opening the domestic market to international competition would facilitate technology diffusion and accelerate the country's catching-up process, which could be vital for human capital development.

In addition to liberalisation of trade, services, and investment, free flow of data in the online marketplace will be one of the components of an open economy in the digital age. The consequent concerns, such as privacy, consumer protection, competition, and cybersecurity, call for international rules and norms on data governance that will affect not only the cross-border flow of data, goods, capital, and services, but also regulation in the domestic market.

According to ECIPE (2018), Indonesia is one of the countries with the most restrictive digital policies based on its score on the Digital Trade Restrictiveness Index.[3] To most foreign investors, the host country's information technology policies that affect business operations and competitiveness are indeed barriers to companies' efficiency improvements or entry to the new markets (Deloitte and AmCham China, 2019). Indonesia could consider promoting foreign investment by lowering restrictions on access to online tools, the use of virtual private networks (VPNs), internet censorship and restrictions, or data localisation requirements.

[3] The Digital Trade Restrictiveness Index lists China, Russia, Indonesia, India, and Viet Nam as the top 5 in the world in terms of the most restrictive digital policies.

4. SUPPORTING SKILLS DEVELOPMENT

Indonesia has a large amount of young labour, with a high literacy rate. This could be a bonus for development if they have the skills to meet market needs. In the digital era, this includes capacity for using digital tools, understanding data-driven business, and managerial skills in global value chain coordination.

With advances in artificial intelligence, robotics can handle not only routine operations, but more and more non-routine jobs such as new product design and production process optimisation. Digitalisation also tends to shorten the metabolising cycle of knowledge – high skills that only experts used to have become common knowledge or basic skills needed to enter the job market. For that reason, human capital that is competitive in the digital economy must be able to learn quickly about new technologies and business models that continuously emerge in the market. Free movement of skilled labour will be helpful for knowledge diffusion.

Different conditions and facilities for lifelong learning and training could also create a digital divide in Indonesia. Embracing new technology in the country's education and training system, such as online learning and teleconferences, would help narrow such differences.

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