3. Harnessing New Technologies for Social and Economic Progress toward ASEAN 2040

Hidetoshi Nishimura, Masahito Ambashi, Fusanori Iwasaki, and Mitsuhiro Maeda

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Harnessing New Technologies for Social and Economic Progress Towards ASEAN 2040[1]

Hidetoshi Nishimura,
Masahito Ambashi,
Fusanori Iwasaki,
Economic Research Institute for ASEAN and East Asia

Mitsuhiro Maeda,
Advanced Institute of Industrial Technology

Discussion Points

- What is the prospect for new technologies in a changing world?
- How can ASEAN fill the gap and catch up with countries in the vanguard of new technologies and achieve relevant industrial development?
- How can ASEAN maximise the opportunity of new technologies?

[1] In writing this paper, we obtained a great number of ideas by exchanging opinions with officials of the Ministry of Economy, Trade and Industry (METI) of Japan, Professor Tomoyuki Higuchi (Director-General of the Institute of Statistical Mathematics), and Professor Yasuyuki Nishioka (Faculty of Engineering and Design, Hosei University) on 20–22 June 2018. In particular, we received valuable relevant materials from the METI. We would like to thank all who contributed to this paper. The views expressed in this paper are our own and do not represent those of any governments or organisations, and remaining errors are totally attributed to us.

1. Introduction

The idea of creating innovation by taking advantage of new technologies, thereby improving productivity and promoting economic growth, has been widely accepted by academia, policymakers, and the private sector. It was argued that innovation and new technologies were not necessary for developing countries because of difficulties in fully using and managing them (Fagerberg et al., 2010). However, such a growth opportunity has been opened not only to developed countries but also to emerging countries, including ASEAN Member States (AMS), through enabled simpler application of them to businesses and industries. This is evidenced by ASEAN's stress on productivity-driven growth, innovation, research and development, and technology commercialisation (B.4) in the ASEAN Economic Community Blueprint 2025 (ASEAN Secretariat, 2015). The important point is to recognise that it may possible for AMS to achieve drastic, discontinuous, and leapfrogging development (cf. step-by-step development) if they can cleverly utilise new technologies and the outcomes of innovation.

It seems that information technology (IT) and communication technology (CT) have different implications for industrial society. Put simply, whereas IT reduces the number of tasks and performs routine non-cognitive tasks at a low cost through the use of computers, CT lowers the face-to-face communication cost and overcomes physical distance through mobile devices linked with high-speed Internet. This information and communication technology (ICT) have made serious changes in existing industrial structures. The most important consequence of ICT is deemed to be the 'third unbundling', a new type of globalisation, where person-wise division of labour and resultant service outsourcing from developed to developing countries.

Accordingly, since the beginning of the 21st century, disruptive new technologies have been emerging in tandem with the progress of ICT as well as extensive computer and Internet capacities. As a series of new technologies have expanded to the field of ICT, the speed of modern industrialisation has accelerated. These digital technologies include the internet of things (IoT), big data, and artificial intelligence (AI), which are expected to play a substantial role in innovating and reforming existing

industries in the next 20 years. The effect of ICT has penetrated beyond the internet space to 'traditional' industries such as finance, agriculture, medical and health care services, and conventional manufacturing. Given this rapid digital technological development, we may witness critical changes in both industries and societies in 2040 that are beyond our imagination.

This new type of industrialisation in the 21st century is frequently called the Fourth Industrial Revolution and it could be totally different from the past three industrial revolutions (Schwab, 2017). Some authors insist that the Fourth Industrial Revolution is a buzz word and that its impact is exaggerated. However, we believe that it has great potential not only to facilitate the economic transformation of ASEAN based on new technologies, but also to markedly increase society's ability to address social problems and promote social progress in a more efficient and effective manner. This social progression will be encouraged through customisation of products and services provided for individuals by integrating analogue hardware with digital software technologies. Concretely, potential innovations can be found in future-oriented robotics, drones, bioindustry, automated driving systems, educational technology (EdTech, an educational method based on ICT), and blockchains (decentralised, distributed, and public digital ledger), as discussed later.

This paper provides a brief overview of new technologies and examines the challenges and opportunities for ASEAN in providing favourable environments that encourage the adoption and adaptation of new technologies and innovations. We emphasise that ASEAN and its member states need to establish their own innovation ecosystems (i.e. innovation hubs), linked to the rest of the world, so that the private sector in ASEAN can make full use of new technologies in collaboration with the innovation enterprises of the United States, Japan, China, and other countries. Developing a way to address inherent social problems, such as ageing, traffic, and environmental pollution, in ASEAN is also an important issue. In short, we argue that ASEAN and its member states need to improve, catch up, and adopt and adapt new technologies to the varying conditions of the diverse region, while setting up distinguishing innovation ecosystems that leverage their advantages. Towards this end,

AMS may need to consider regulatory sandboxes[2] and encourage joint projects with technology leaders.

This paper is organised as follows. Section 2 presents the current situation surrounding technological development, focusing on four promising key new technologies. Section 3 highlights applications of new technologies to industry and illustrates the state of industrialisation. Section 4 discusses the direction that ASEAN and its member states need to follow regarding new technologies, with a view to consolidating their unique innovation ecosystems. Section 5 makes concluding remarks.

2. What Happens Now in the World?

The advance of the Fourth Industrial Revolution revolves around four technological fields–(1) IOT, (2) big data, (3) AI, and (4) robotics–which have achieved remarkable technological and industrial evolution. Among other things, it is becoming possible to obtain a great deal of big data about products, plants, and daily business operation levels on site; conduct statistical analyses of such data; and take effective actions based on the analyses, thanks to rapid technological development of ICT (Ministry of Economy, Trade and Industry of Japan (METI), 2017).

(1) **IOT**: The popular definition of IoT is the network of physical devices and other items embedded with digital devices (e.g. electronics, software, sensors, and actuators) and the ability of these devices to connect each other and exchange data with distributed intelligence (Atzori, et. al, 2010; Santucci, 2010; Gubbi et al., 2013). Information obtained from manufacturing production and operation can be accumulated as useful data throughout the IOT system. Such data helps us control the system of IOT and conduct remotely-connected and diversified manufacturing production and operation through the linkage of internet networks, which is expected to realise highly digitalised economies, industries, and societies.

[2] The regulatory sandbox is a kind of deregulation that temporarily halts the application of regulations stipulated by current legislation for limited stakeholders with an aim to create innovative new businesses through pilot projects. This system was first introduced in the UK for Fin Tech services and has now expanded to regions such as the US, Singapore, and Australia.

(2) **Big data**: This includes a variety of non-structured and non-stylised data being generated and recorded on a real-time and time-series basis. Vast information associated with big data exceeds the ability of commonly used software tools, existing data analysis approaches, and typical manage and storage data systems within a tolerable elapsed time (Snijders, Matzat, and Reips, 2012). More importantly, big data alone does not create any value added unless it is employed in a beneficial manner to facilitate real business or social planning. So, if we intend to make use of big data for real activities, we need to create new value added by developing customised marketing plans while conducting a simultaneous data analysis (Varian, 2014; McAfee and Brynjolfsson, 2012).[3]

(3) **AI**: This is also sometimes called machine intelligence, displayed by computers and machines, in contrast to natural intelligence demonstrated by human beings and other animals. The term AI is typically used when a machine simulates cognitive functions such as learning and problem solving (Nilsson, 1998; Russell and Norvig, 2009). The idea of developing AI as a national policy project has a long history that dates back to the 1980s.[4] Computers equipped with AI can engage in a variety of very advanced tasks (e.g. interpretation of speech, driving, drug discovery, and optical character recognition) and can expedite an instant decision making that is difficult and generally beyond the ability of human beings by using deep learning through which computers learn by themselves for better decision making.[5]

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[3] Varian (2014) indicates that taking full advantage of big data requires increased sophisticated knowledge about what to do with the massive amounts of data which are now available. McAfee and Brynjolfsson (2012) emphasise a change in decision-making culture to radically improve enterprises' performance.

[4] In 1980s Japan, supercomputers equipped with AI based on natural language (fifth generation computers) was promoted in collaboration with government research institutes and the private sector.

[5] Deep learning is a kind of machine learning based on learning data representations. It solves problems by introducing and extracting representations that are expressed in terms of other, simpler, and more meaningful representations from data (Goodfellow, Bengio, and Courville, 2016).

(4) **Robotics**: This is formed by an intersection of various technologies including mechanical engineering, electronic engineering, and computer science. The design, fabrication, and operation of robots are studied based on these technologies. The aim of robotics is to create machine robots that can replace human beings or their tasks with physical suffering in dangerous construction sites, manufacturing processes, and even education systems (Nocks, 2008). Robots are expected to perform complex, diversified, and hazardous tasks done by human beings previously.

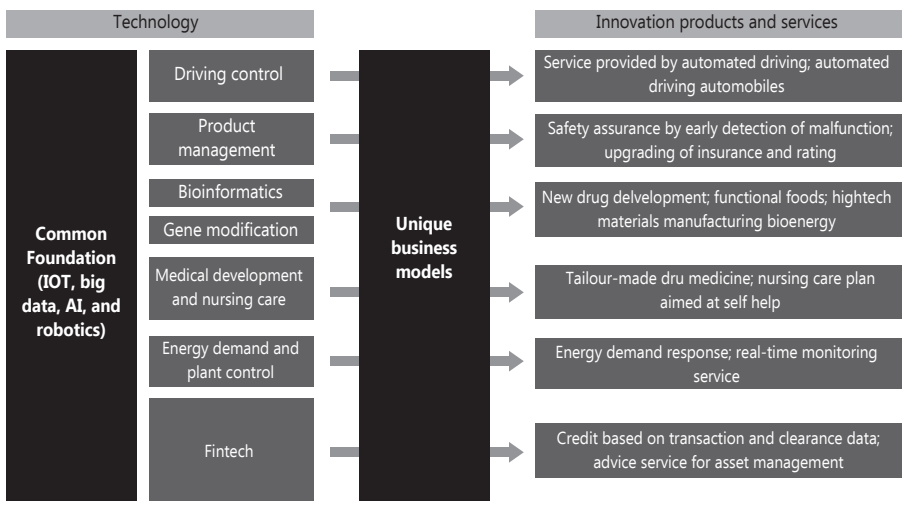
These new technologies, which constitute the core of the Fourth Industrial Revolution, are the common technological foundation for next-generation industries to emerge and prosper. To fill the gap between using new technologies and producing innovative products and services, a tight association with a variety of 'existing' technologies based on the common foundation (IOT, big data, AI, and robotics), and unique business models is indispensable (Figure 1).

Thanks to technological development ushered in by ICT that facilitates lively interactions between suppliers and consumers, we can more easily identify social structural problems that have not explicitly appeared as obvious demand from people. Suppliers can perceive such problems as true social needs of consumers and can transform them to real businesses. For example, many newly emerging IT platform firms in ASEAN, such as Lazada (e-commerce and online shopping), GO-JEK (ride-hailing transport services, food delivery, payment solutions, etc.), and Grab (similar on the GO-JEK), have become profitable by discovering social needs and providing possible service solutions. In other words, these platform firms employ ICT to establish markets which connect supply with demand, and confront socioeconomic challenges such as financial transactions and transportation.

The way in which global and local firms respond to the Fourth Industrial Revolution is highly likely to affect their productivity and competitiveness in the global marketplace. Manufacturing and service provision, which generates high value added, and newly emerged markets would promote further value addition and productivity improvements. In the

'smile-curve' relationship between the value chain (horizontal axis) and value added (vertical axis), there is the possibility of realising high value addition across all three value chains of (1) material, (2) production and fabrication, and (3) services. Even in the production and fabrication stage, which tends to be low value added in common understanding, making unique manufacturing products with high value added would be feasible through an innovative combination of existing and digital production technologies. More importantly, platform firms have entered into various markets across sectoral borders within value chains by providing business platforms (application software, contents, and others) in which suppliers are efficiently matched with customers. As a consequence, we will witness an inevitable change in industrial structures and business models along every value chain.

Figure 1: Comparison of Real GDP Growth Rates (%)



AI = artificial intelligence, IOT = Internet of Things.

Source: Author's compilation in reference to METI (2017b).

Further, where technological development and industrial structures change and accelerate rapidly, 'flexible' firms, especially ventures like start-ups which can continuously reform their business models, resources, and projects, lead radical innovation by overcoming the so-called 'innovator's dilemma'.[6] In contrast, large, mostly old, firms (e.g. department stores and taxi service firms) encounter difficulties in adapting to new environments where ICT radically destroys the existing business order.

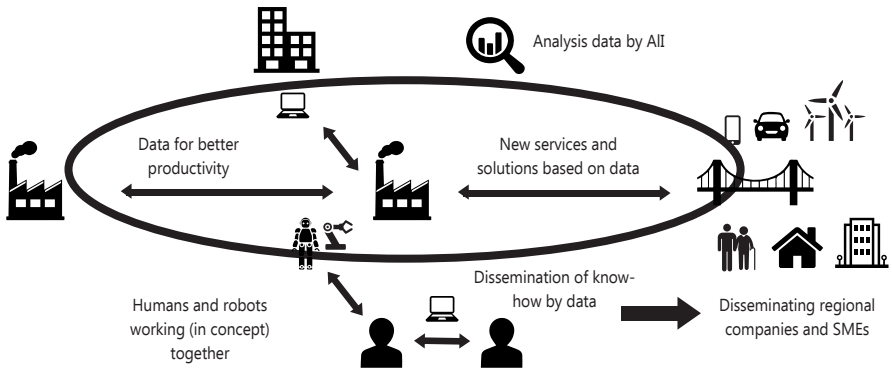
3. Application of New Technologies and Industrialisation

In the industrial society of the future, it is anticipated that business facilities, plants, and factories will be connected with each other in terms of skills, technologies, and consumer preferences (which have not been necessarily connected), and that such close connection will dramatically increase technological development, productivity improvement, and skills transfer among workers. For example, the following impacts of 'Connected Industries' are generally assumed in the Fourth Industrial Revolution, as illustrated in Figure 2 (METI, 2017a; pp. 4):

- 'Firm data' stocked among diversified plants, facilities, and sections will be connected with each other.
- 'Consumer data' on provided products and services will be connected with suppliers and is expected to contribute to firms' productivity improvements.
- Data analysed by AI will be utilised for further technological development, productivity improvement, and competitiveness enhancement.
- AI and robotics introduced into on-site jobs will work harmoniously with human workers.
- Digitalised skills will be easily and efficiently transferred to next-generation workers.

[6] Christensen (1997) argues that small entrepreneur firms put themselves in more favourable positions than large incumbent firms in terms of seizing the next wave of innovation in their respective industries because the former firms can avoid cannibalisation, which destroys the outcomes of existing innovations.

Figure 2: Concept of 'Connected Industries'



AI = artificial intelligence, SMEs = small and medium-sized enterprises.
Source: METI (2017a).

As described in the abovementioned case of connected industries, it is likely that AMS will also be able to develop and upgrade their industrial and export structures equipped with new technologies associated with IOT, big data, AI, and robotics. Since industries of AMS are firmly incorporated into global/regional value chains and production networks, they have significant potential to enhance their industries in tandem with surrounding economic partners. In this regard, more emphasis should be put on accepting cooperation provided by industrially advanced countries such as the United States (Silicon Valley), Japan (Connected Industries), Germany (Industry 4.0), and China (Made in China 2025).

Potential new technologies and their applications include the following:

- **Future-oriented robots**: These robots are defined as 'intelligent machinery systems' which possess three elemental technologies: intelligence, control systems, and drive systems (METI, 2006). They are also roughly categorised into industrial robots (e.g. welding, equipping electronic parts) and service robots (e.g. business and livelihood support, nursing care). When it comes to using robots, there is huge potential not only to drastically raise productivity and cut the costs of manufacturing plant lines but also to promote service industries generally suffering from low productivity. Additionally, using robots in infrastructure development and maintenance and disaster

recovery would be useful for ASEAN, one of whose policy challenges is to enhance 'resilience' and 'responsiveness' to social requirements. For instance, checkout and repair works using robot power will be practical, without depending on human engineering workers, at dangerous disaster sites.

- **Uninhabited airborne vehicle (i.e. drone)**: Drones, controlled in indirect operation without attended human pilots, are devised for various objectives, i.e. policing, land surveillance, product delivery, aerial photography, scientific research, and agriculture in addition to the military affairs. For example, home delivery of daily essentials such as food, clothes, and medicines by drones will vitalise distribution logistics. For ASEAN, which has many remote islands and mountainous villages, it is hoped that drones will play a role in enhancing connectivity between urban and rural areas.[7] Moreover, drones specialised in agriculture can be used for soil and field analysis, planting, crop spraying, crop monitoring, irrigation, health assessment, and so on.

- **Biotechnology**: Biological innovation has been generated in agriculture, food production, and medicine. In recent years, because of technological advancement, biotechnology has expanded to applications such as gene modification and editing, recombinant gene techniques, cellular fusion, immunology, and development of pharmaceutical therapies and diagnostic tests. Since AMS have diversified affluent biological resources in the (sub)tropical region, there seems to be much leeway for them to develop natural drugs through the use of such resources.[8] In industrial sectors, the application of biotechnology will help innovate in production processes; productivity improvement; pollution reduction; and recycling of wastes for a circular economy through making industrially useful products such as foods, chemicals, and textiles. 'Bioinformatics' is also expected to address problems in the pharmaceutical sector by combining biotechnology with ICT.

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7 Strickland (2018) reported that vaccines would be delivered to local people by drones in isolated island villages of Vanuatu.

8 The Bogor Agricultural University conducts research on developing new drugs made from indigenous plants in Indonesia that prevent epidemic of living stocks (The Nikkei, 2018).

- **Automated driving system**: This system attempts to control automotive travel, based on enhanced cognitive and judgement abilities which can imitate human drivers' perception, decision making, and operation of the automobile. The automated driving system requires advanced information processing, real driving, big driving data, and awareness of surroundings under the complex systems of AI. The ultimate objective of this technology is to achieve a safe, untroubled, and environmentally friendly 'mobility society'. The main benefit is its potential contribution to mitigating traffic problems, which have troubled many AMS. In recent years, the alignment driving system of tracks, control technology of inter-vehicular distance, and automated driving architecture based on AI have been under study in countries such as the US (e.g. Amazon, Google, and Uber), China, and Japan for practical use in the near future.

The infrastructure of ASEAN to use these new technologies fully–such as physical and soft infrastructure including institutions, laws, and regulations; potential industries and firms in domestic marketplaces; and skilled human resources–is far behind that of advanced countries (which have not necessarily fully achieved the infrastructure). With a view to enhancing infrastructure, it is essential that the governments of AMS arrange: institutions, laws, and regulations and rules regarding the use of big data and AI as well as applications of new technologies like drones; incentive mechanisms to promote applications (e.g. subsidies and tax incentives for R&D, and grants for targeted innovation); nurturing existing micro, small, and medium-sized enterprises (MSMEs) to form domestic supporting industries; and capacity building programs for workers who can lead new technologies.

Among other things, human resources should be developed to create innovations using new technologies. In the new era of AI and big data, governments of AMS need to produce talented workers who can not only figure out how to use AI and big data on the basis of mathematical abilities, but also can create unique values by setting appropriate frameworks, enhancing general abilities to identify and solve problems, and using universal abilities that are not easily replaced by machines. Mechanisation has heavily impacted low-skilled workers so far, but AI and robotics may replace the jobs and tasks of medium-skilled workers such

as middle managers in the near future.[9] For no one to be left behind from new technologies, it is necessary to provide people, including general workers, with enough educational opportunities to receive 'recurrent education', while reforming existing elementary and higher education systems is also an urgent issue.

EdTech is an educational method based on ICT that has been attracting attention. It aims to bring about innovation in education based on new technologies, represented by advanced ICT, to achieve effective education. EdTech targets areas such as infant intellectual stimulation, curriculum support for school children, and English conversation and computer programming classes for business persons. Concrete examples include the delivery of online lectures by leading global universities, adaptive learning systems that offer study content customised for individual students in primary and secondary education, and management platforms for instructors that control the learning progress of students. By using such educational innovation, governments of AMS will be able to promote human resources development efficiently in response to the emergence of new technologies and applications, and thereby narrow educational gaps between urban and rural regions.

The following box illustrates policy applications for new financial technology–blockchains–to enhance the nexus of cross e-residency system in ASEAN (i.e., provision of multi-citizenship and administrative services among AMS based on the blockchain technology).

[9] Brynjolfsson and McAfee (2011) and Frey and Osborne (2017) argue that AI may replace the task of information analysis or judgement conducted by so-called white-collar workers.

ASEAN People's Vision, ASEAN Community, and ASEAN Identity: the Nexus of Cross E-Residency System Based on Blockchain to Enhance 'ASEANity'

(1) The New ASEAN Identity (ASEANity)

One of the most important tasks to be tackled in the post-ASEAN Economic Community era since 2015 is to foster the new ASEAN identity, attached to an integrated entity of ASEAN, in addition to each national identity. The new ASEAN identity may be called 'ASEANity' and citizens in ASEAN member states (AMS) would be 'ASEANians'. The integrated entity of ASEAN would be of ASEANians, by ASEANians, and for ASEANians.

In the past, fostering a new identity took a long time and involved spending huge amounts of capital. For example, before the Meiji Revolution in Japan in 1868, people living on the Japanese islands held provincial identities. After the revolution, however, Japan established a strong centralised government backed by a strong 'Japanese' identity. The Japanese identity was the invention of the central government of Japan, which spent a huge amount of budget fostering it for decades.

In the 21st century, we can apply the latest disruptive information and communication technology (ICT) to this issue. Our recommendation is to adopt blockchain technology. By employing a blockchain, we would be able to develop a new ASEAN identity in a short time with relatively small amounts of capital. We propose establishing the 'nexus of cross e-residency' system based on a blockchain to foster a new ASEAN identity, i.e. ASEANity.

(2) The 'Nexus of Cross E-Residency' System

In fostering the new ASEAN identity, one of the most important requirements would be 'understanding' other AMS, including their respective culture, history, formal and non-formal social institutions, and way of thinking. The best way to enhance understanding would be to become a citizen of those AMS. In other words, people living in ASEAN would hold multi-citizenship of several AMS in addition to their original

citizenship. A citizen of one AMS (AMS-a) would hold citizenship of other AMS (AMS-b, AMS-c, etc.) and enjoy the administrative services of AMS-b, AMS-c, etc., in addition to the administrative services of the original AMS-a. This multi-citizenship may be called 'hyper people-to-people connectivity'.

Holding such multi-citizenship and enjoying administrative services from various AMS is important for people who act cross-nationally, e.g. business people or academics. We believe that this system would help all people living in ASEAN understand other AMS. Such cross-national understanding would lead people to 'create' or be 'aware' of ASEANity.

Establishing this system would invite a kind of 'popularity competition' among AMS. A popular AMS would be able to attract many people in ASEAN to obtain citizenship. An AMS which attracts only a small number of people would be forced to undertake reform policies, especially in the area of administrative services for residents. As a result, many people in ASEAN would hold multi-citizenship in ASEAN. Large numbers of people would hold 'complete' citizenship (i.e. of all 10 AMS). Through obtaining citizenship of other AMS, people would understand the cultural, historical, and social background of other AMS to become and act as 'good citizens' there. This mutual understanding would be the basis for ASEANity.

This mechanism shows the bottom–up, decentralised strategy of fostering identity. Considering the character of the concept of identity, we argue that this strategy has a significant advantage over the centralised strategy.

(3) Technical Background

(i) Blockchain technology

Blockchain is a distributed ledger technology on a peer-to-peer network, based on technology including consensus algorism, smart contract, or encryption. The structure of a blockchain is decentralised, without big databases, and provides a high level of visibility and reliability on the

internet platform. A blockchain enables people to share a huge amount of information at a low cost, with confidentiality guaranteed.

In establishing the nexus of cross e-residency system, we recommend introducing a total e-government system covering not only each AMS but also the integrated entity of ASEAN based on a blockchain.

(ii) Structure of the three-layered system

We propose establishing a three-layered system: the first layer is the e-government system of each AMS, the second is the harmonised system of each e-government system, and the third is the integrated system of ASEAN.

The first layer is a blockchain-based e-government system in each AMS. On this layer, the main task is to establish an e-government system in each economy based on a blockchain.

Estonia is famous for its e-government system based on blockchain. We can obtain many lessons from the Estonian e-government case, despite the difference between Estonia (a single economy with a population of 1.3 million) and ASEAN (10 economies with a population of more than 600 million). We can follow the Estonian e-government case while modifying it or adding some functions. The strategy on this layer will be called 'the Expanded Estonian Model'. At this stage, each AMS will develop its original e-government system, partially based on blockchain, using a standardised e-government system, i.e. the ASEAN Standard Model of e-government.

The second layer is the harmonisation of each AMS e-government system by introducing the bridge system. This layer will be called the 'ASEAN Information Sharing System'. Each AMS government is requested to categorise the personal information of their people in three categories: highly confidential, open to domestic people, and open to all people in AMSs. The ASEAN Information Sharing System will provide the third category of personal information to all people in AMS.

Finally, the third layer is the integrated operation layer, where the headquarters of the ASEAN integrated entity will operate. This headquarters will oversee the operation of various region-wide administrative services based on the first and the second layers. Typical services could include the following:

- An ASEAN cryptocurrency. After the Asian financial crisis in 1997, many ideas have been developed for a common currency in East Asia, including a kind of basket currency or Asian currency unit. Researchers raised the issue of information sharing regarding a common currency, but a blockchain could substantially solve this problem since it is distributed ledger technology. A new cryptocurrency could be used in intergovernmental settlements among AMS at the first stage, intergovernmental agencies settlements at the second stage, and between large private enterprises settlements at the third stage. Settlements among SMEs and the public would follow later.
- Integration of operating people's health records.
- Common education systems or curricula would be operated in a variety of educational institutions in AMS.
- Joint operation of manufacturing factories by IOT. This is also known as the cyber physical system where all systems are controlled by computers to improve the efficiency of the society and create new inudstries. ASEAN will be able to operate this system at the regional (transnational) level, which might be called 'Industry 4.0 Plus (4.0+)'.

4. Way Forward for ASEAN and its Member States with New Technologies

Towards 2040, Silicon Valley, which still dominates other countries and cities in the development of AI and big data, may continue to play a leadership role in digitalising all sorts of industries and may monopolise radical innovation outcomes led by new technologies. It is also highly likely that fierce global competition will take place for 'innovation ecosystems' among countries and cities with respect to practical applications of new technologies to innovations in real businesses and socioeconomic progress.

Practical applications of modern ICT have been occurring all over the world based on high-speed internet, cloud computing, and smartphones. In line with the above-mentioned four fundamental new technologies (i.e. IOT, big data, AI, and robotics) and financial technology such as blockchain, diversified innovation ecosystems are being formed in countries and cities to escalate into more elaborate industrial sectors and markets as an experimental application of these technologies (e.g. agriculture, health care, fintech, and manufacturing). AMS should catch up, customise, and disseminate new technologies to local firms and MSMEs, especially 'technology entrepreneurs', to innovate distinguishing business models that better leverage their advantages, such as thick consumer markets supported by increasing middle and upper groups, the sheer diversity of the region, and young talent that is familiar with ICT.

The critical element of the Fourth Industrial Revolution builds mainly on the software developed around ICT, which allows for customisation to a greater extent on the hardware. For example, the design of a drone used for a tropical multi-crop system frequently observed in ASEAN might be different from that for a monoculture agricultural system in other regions. This room for customisation would call for strenuous efforts to produce innovations geared to the characteristics of a country, subregion, or even a large city in ASEAN. Therefore, AMS should have enough capacity to innovate with effective customisation adapted to the region, and then to render their products, services, and business models transferable and saleable to the rest of the world with similar characteristics beyond the region. This innovation ecosystem is what ASEAN should seek to

leverage its competitive advantage and establish its position as a global 'innovation hub' in 2040.

Lastly, in the Fourth Industrial Revolution centring on new technologies, AMS need to develop new frontiers of potential market to be targeted by innovative business models and thereby realise an affluent society for all people. Meanwhile, it might be essential for AMS to rebuild the whole socioeconomic system including institutions, laws, regulations, and rules, particularly from the viewpoint of strengthening capacity building of human resources and facilitating the movement of young talent, to adapt to the era of new technologies. Thus, for ASEAN and AMS to obtain the full benefits, a holistic approach is needed to formulate unique innovation ecosystems. In this regard, we do not have much time left to achieve that goal before 2040.

5. Concluding Remarks

From the discussions so far, the key messages of this paper are concluded as follows:

In the first place, the new technologies–IoT, big data, AI, and robotics–will constitute the technological foundation for next-generation innovation in association with innovative business models. Through these technologies, AMS can identify social and structural problems that have not appeared as obvious and create new markets that satisfy real demand. To this end, AMS need to arrange: institutions, laws, and regulations and rules for the use of AI and big data; incentive mechanisms to promote practical applications of new technologies; nurturing existing MSMEs to form domestic supporting industries; and capacity building programs for workers who can lead new technologies. It is also worthwhile to receive industrial cooperation from the United States, Japan, China, and others.

The opportunity to employ new technologies and innovations are equally opened to countries and cities other than ASEAN. Towards 2040, it is likely that AMS will face fierce competition among them for innovation ecosystems that realise socioeconomic progress. AMS is

required to immediately start nurturing local firms, especially technology entrepreneurs, to innovate distinguishing ecosystems that better leverage their advantages, such as thick consumer markets and diversified societies. On the other hand, AMS also need to establish innovation hubs and produce their 'own innovations' geared to their characteristics through effective customisation of new technologies. By doing so, AMS are expected to render their products, services, and business models transferable and saleable to the rest of the world with similar characteristics beyond the region.

Goals and policy recommendations

Goals	Policy recommendations
• Survive global competition for "innovation ecosystems" among countries and cities with respect to practical applications of new technologies to innovations in businesses and socioeconomic progress. • Catch up, customize, and disseminate new technologies to local MSMEs, especially "technology entrepreneurs", to innovate distinguish business models that better leverage ASEAN's advantages. • Form "innovation hubs" that render products, services, and business models transferable and saleable to the rest of the world.	• Arrange (1) institutions, laws, and regulations and rules for the use of new technologies, particularly, big data and AI; (2) incentive mechanisms to promote applications (e.g. subsidies and tax incentives for R&D, grants for targeted innovation; (3) nurturing existing MSMEs to form domestic supporting industries; and (4) capacity building programs for workers who can lead new technologies. • Receive industrial cooperation from countries, such as Japan, Germany, and China. • Produce talented workers who can not only figure out how to use new technologies but also create innovations. • Provide people with enough educational opportunities from elementary school to 'recurrent education' with support of new educational methods such as 'EdTech'.

References

ASEAN Secretariat (2015), *ASEAN Economic Community Blueprint 2025*, Jakarta: ASEAN Secretariat. https://asean.org/?static_post=asean-economic-community-blueprint-2025 (accessed 28 November 2018)

Atzori, L., A. Iera, and G. Morabito (2010), 'The Internet of Things: A Survey', *Computer Networks*, 54(15), pp.2787–805.

Brynjolfsson, E. and A. McAfee (2011), *Race Against the Machine: How to Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. Lexington, MA: Digital Frontier Press.

Christensen, C.M. (1997), *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston, MA: Harvard Business Review Press.

Fagerberg, J. and M. Srholec, and B. Verspagen (2010), 'Innovation and Economic Development' in B. H. Hall and N. Rosenberg (eds.), Handbook of Economics of Innovation, Vol. 2. Amsterdam: Elsevier, pp.834–72.

Frey, C.B. and M.A. Osborne (2017), 'The Future of Employment: How Susceptible are Jobs to Computerisation? Oxford University Programme on the Impact of Future Technology', *Technological Forecasting and Social Change*, 114(C), pp.254–80.

Goodfellow, I., Y. Bengio, and A. Courville (2016), *Deep Learning*. Cambridge, MA: The MIT Press. http://www.deeplearningbook.org/ (accessed 28 November 2018)

Gubbi, J., R. Buyya, S. Marusic, and M. Palaniswami (2013), 'Internet of Things (IoT): A vision, architectural elements, and future directions', *Future Generation Computer Systems*, 29(7), pp.1645–60.

McAfee, A. and E. Brynjolfsson (2012), 'Big Data: The Management Revolution', *Harvard Business Review*, October, pp. 59–68. https://hbr.org/2012/10/big-data-the-management-revolution (accessed 28 November 2018)

METI, Japan (2006), *Report on Robot Policy Study Group*, Tokyo: Ministry of Economy, Trade and Industry (in Japanese). http://warp.da.ndl.go.jp/info:ndljp/pid/286890/www.meti.go.jp/press/20060516002/robot-houkokusho-set.pdf (accessed 28 November 2018)

METI, Japan (2017a), *'Connected Industries': Tokyo Initiative 2017*, Tokyo: Ministry of Economy, Trade and Industry (in Japanese).http://www.meti.go.jp/english/press/2017/pdf/1002_004b.pdf (accessed 28 November 2018)

METI, Japan (2017b), *The New Industrial Structure Vision: Japan as a Future-Oriented Country Solving Global Challenges on an Individual Basis*, Tokyo: Research Institute of Economy, Trade and Industry (in Japanese).

Nilsson, N. (1998), *Artificial Intelligence: A New Synthesis*. San Francisco, CA: Morgan Kaufmann Publishers.

Nocks, L. (2008), *The Robot: The Life Story of a Technology*. Baltimore, MD: Johns Hopkins University Press.

Russell, S. and P. Norvig (2009), *Artificial Intelligence: A Modern Approach*, 3rd edition. Upper Saddle River, NJ: Princeton Hall.

Santucci, G. (2010), 'The Internet of Things: Between the Revolution of the Internet and the Metamorphosis of Objects', European Research Cluster on the Internet of Things. http://www.internet-of-things-research.eu/documents.htm (accessed 28 November 2018)

Schwab, K. (2017), *The Fourth Industrial Revolution*. New South Wales: Currency Press.

Snijders, C., U. Matzat, and U.-D. Reips (2012), ''Big Data': Big Gaps of Knowledge in the Field of Internet Science', *International Journal of Internet Science*, 7(1), pp.1–5.

Strickland, E. (2018), 'Drone Delivery Becomes a Reality in Remote Pacific Islands', *IEEE Spectrum*, 31 May. https://spectrum.ieee.org/the-human-os/biomedical/devices/drone-delivery-becomes-a-reality-in-remote-pacific-islands (accessed 28 November 2018)

The Nikkei (2018), 'The Research Institute of Tropical Biopharmaceutical Manufacturing of the Bogor Agricultural University Studies New Drags Derived from Plants' 21 November 2018 (in Japanese).

Varian, H. (2014), 'Beyond Big Data', *Business Economics*, 49(1), pp.27–31.