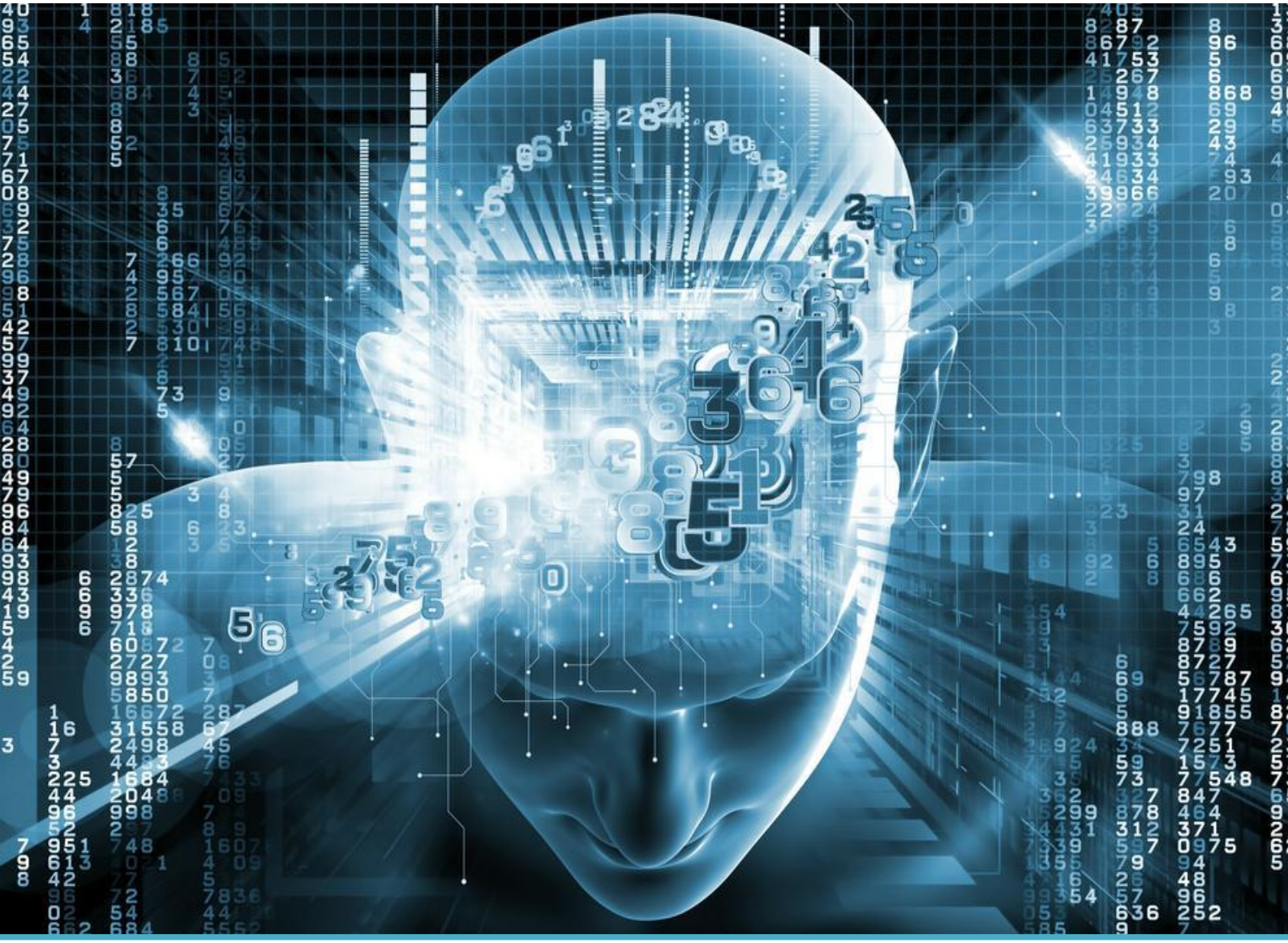
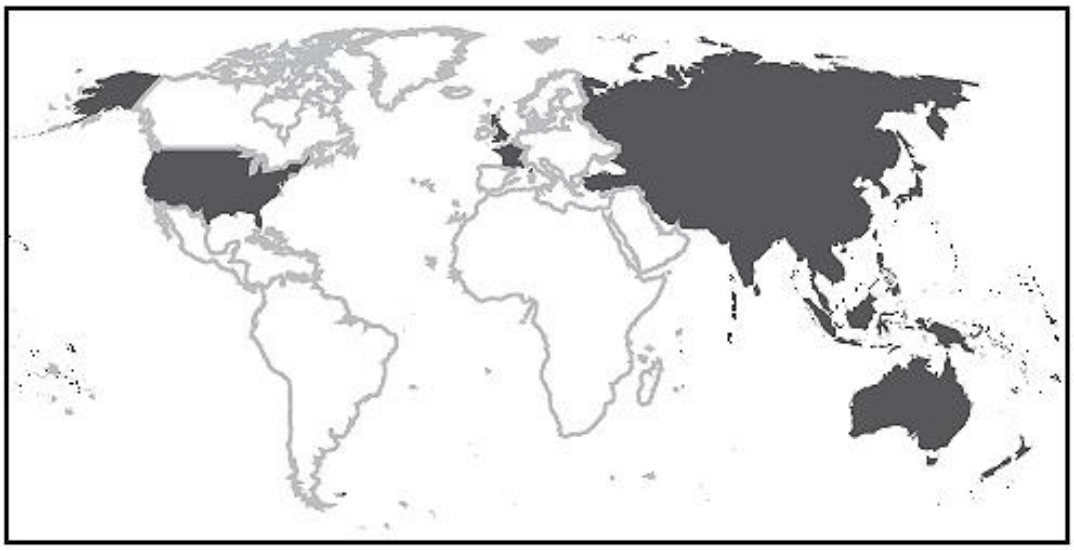


Artificial Intelligence

in Asia and the Pacific

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific

The Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations' regional hub promoting cooperation among countries to achieve inclusive and sustainable development. The largest regional intergovernmental platform with 53 member States and 9 associate members, ESCAP has emerged as a strong regional think-tank offering countries sound analytical products that shed insight into the evolving economic, social and environmental dynamics of the region. The Commission's strategic focus is to deliver on the 2030 Agenda for Sustainable Development, which it does by reinforcing and deepening regional cooperation and integration to advance connectivity, financial cooperation and market integration. ESCAP's research and analysis coupled with its policy advisory services, capacity building and technical assistance to governments aims to support countries' sustainable and inclusive development ambitions.



FOREWORD

Concerns regarding the economic implications of emerging technologies are nothing new. Textile workers destroying looms in nineteenth century England for fear of losing their jobs and robots displacing workers on assembly lines, are just two examples from past industrial revolutions. As we enter the Fourth Industrial Revolution, a revolution defined by frontier technological breakthroughs, there is a prevailing narrative that, this time, the changes could have a much more profound impact.

However, frontier technologies could have significant positive impact for society and the environment. For example, data suggest that improved application of information and communication technologies to smart grids and transportation will reduce carbon emissions by an estimated 4.5 billion tons by 2020.

In this context, this paper reviews the status of a specific frontier technology, artificial intelligence (AI), in the Asia-Pacific region and discusses the policy implications. The paper points out that a new "frontier technology divide" should be the primary concern for the region. Advanced or large economies in the region are embracing and investing in AI at astonishing rates. There is a risk that developing countries could get left behind.

This paper also highlights the "trust deficit" as a key issue to tackle. Data is the fuel for AI development. In this data revolution, policies that address data trust between governments, private sector, civil society and citizens will be fundamental to AI's evolution.

AI will have far reaching consequences across the globe. The Asia-Pacific region is leading from the front and is forecast to be the major market of the future. This prominent position, however, means governments in the region need to attach great importance to the role and scope of AI in pursuit of sustainable development. It will be prudent for governments to think carefully about the policy priorities and issues raised in this paper to address ethical dilemmas, develop an adaptable workforce for the future, put in place anticipatory regulation to allow innovation to flourish, incentivise the private sector to act responsibly, and utilise AI to deliver more efficient public services.

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ABBREVIATIONS

AI	Artificial intelligence
CAIIIA	China Artificial Intelligence Industry Innovation Alliance
CPUs	Central processing units
CSR	Corporate social responsibility
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FinTech	Financial technology
GPUs	Graphics processing units
IDC	International Data Corporation
IoT	Internet of Things
MSIP	Ministry of Science, ICT and Future Planning, the Republic of Korea
NLP	Natural Language Processing
OECD	Organisation for European Economic Co-operation
PwC	PricewaterhouseCoopers
R&D	Research and Development
SDG	Sustainable Development Goal
UNCTAD	United Nations Conference on Trade and Development
USA	United States of America

1. What is artificial intelligence (AI)?

1.1 How is AI defined?

There is no universally agreed definition of AI. According to OECD[1] and UNCTAD[2], AI is defined as the ability of machines and systems to acquire and apply knowledge, and to carry out intelligent behaviour. This includes a variety of cognitive tasks (e.g. sensing, processing oral language, reasoning, learning, making decisions) and demonstrating an ability to move and manipulate objects accordingly. Intelligent systems use a combination of big data analytics, cloud computing, machine-to-machine communication and the Internet of Things (IoT) to operate and learn.

AI is a software and generally algorithm based although its functions (e.g. talking or playing a game) need to be reflected by physical substance (such as robots). In this sense, AI is like a human brain. To date, AI development has been generally focused on a selection of specific domains (see Table 1).

Table 1. Major AI domains

Major AI domains	*Description*
Large-scale Machine Learning	Design of learning algorithms, as well as scaling existing algorithms, to work with large data sets.
Deep Learning	Model composed of inputs such as image or audio and several hidden layers of sub-models that serve as input for the next layer and ultimately an output of activation function.
Natural Language Processing (NLP)	Algorithms that process human language input and convert it into understandable representations.
Collaborative Systems	Models and algorithms to help develop autonomous systems that can work collaboratively with other systems and with humans.
Computer Vision (Image Analytics)	The process of pulling relevant information from an image or sets of images for advanced classification and analysis.
Algorithmic Game Theory and Computational Social Choice	Systems that address the economic and social computing dimensions of AI, such as how systems can handle potentially misaligned incentives, including self-interested human participants or firms, and the automated AI-based agents representing them.
Soft Robotics (Robotic Process Automation)	Automation of repetitive tasks and common processes such as customer servicing and sales without the need to transform existing IT system maps.

Source: PwC, Sizing the prize, see: https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html

[1] OECD (2016). OECD Science, Technology and Innovation Outlook 2016. Paris.
[2] UNCTAD (2017), Information Economy Report 2017, see: http://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=1872.

1.2 What can AI do?

AI can augment human capacity by processing and analysing large datasets much faster than humans. For instance, in medical care, AI may help analyse data of a large number individuals and identify patterns for disease diagnosis. In the legal sector, AI is being used to sift court documents and legal records for case-relevant information. In the automobile industry, AI-driven robots have been used on assembly lines. Furthermore, AI has the potential to change the way we live. The most quoted example is the automatic or driverless car (see Box 1 for further information on what AI can offer).

According to PricewaterhouseCoopers (PwC), AI will have huge impacts on the following industries: healthcare; automotive; financial services; retail and consumer; technology, communications and entertainment; manufacturing; energy; and transport and logistics[3].

Box 1. What can AI do?

AI holds immense potential for increasing productivity, most obviously by helping firms and people use resources more efficiently, and by streamlining the way we interact with large sets of data. For example, firms like Ocado and Amazon are making use of AI to optimise their storage and distribution networks, planning the most efficient routes for delivery and making best use of their warehousing capacity. AI can help firms do familiar tasks in more efficient ways. Importantly, it can also enable entirely new business models and novel approaches to old problems. For example, in healthcare, data from smartphones and fitness trackers that is analysed using new machine learning techniques can improve management of chronic conditions as well as predicting and preventing acute episodes of illness.

AI can help both companies and individual employees to be more productive. Routine administrative and operational jobs can be learned by software agents ('bots'), which can then prioritise tasks, manage routine interactions with colleagues (or other bots), and plan schedules. Email software like Google's Smart Reply can draft messages to respondents based on previous responses to similar messages. Newsrooms are increasingly using machine learning to write sports reports and to draft articles. In the office, similar technology can produce financial reports and executive briefings.

AI can reduce the burden of searching large sets of data. In the legal sector, groups like ROSS, Lex Machina and CaseText are using AI to sift court documents and legal records for case-relevant information. Other firms are using similar techniques as part of due diligence.

AI can also offer a way of interacting with these datasets, with platforms such as IBM's Watson able to support expert systems that can answer factual natural language questions. For cybersecurity firms, AI offers a way of recognising unusual patterns of behaviour in a network.

These examples focus on using software to do the same thing as humans but, in many cases, analysing data of volume or complexity that is beyond the analytical capability of individual humans. Indeed, AI is not a replacement, or substitute for human intelligence. It is an entirely different way of reaching conclusions.

AI can complement or exceed our own abilities. It can work alongside us, and even teach us. This offers new opportunities for creativity and innovation. Perhaps the real productivity gain from AI will be in showing us new ways to think.

Source: Growing the Artificial Intelligence Industry in the UK, 2017.

[3] See: https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html#explorer.

1.3 What factors underpin AI development?

Several key factors have combined to speed the evolution of AI in recent years. Apart from large scale investment (covered in Section 2), the following factors have underpinned AI development[4]:

- **Big data:** Big data is essential to enable AI devices to learn. The abundance of data in areas such as healthcare diagnostics and online shopping preferences has provided the fuel to test the potential of AI. Companies such as Amazon, Google, Facebook, Baidu and Alibaba all have access to large amounts of data which enable their AI systems to better understand their customers and provide customised service such as advertisements or promotions.

- **Increasingly powerful computing capacity:** Traditionally, central processing units (CPUs) were the standard for interpreting and executing commands in servers, tablets, computers and mobile phones. The development of machine learning and deep learning has been boosted by graphics processing units (GPUs), which have the ability to perform many calculations simultaneously or in parallel, speeding up training processes. For example, Google DeepMind's AlphaGo algorithm was run on multiple machines using 1,202 CPUs and 176 GPUs enabling it to beat the world champion of the Chinese board game Go[5].

- **Advanced algorithms and software:** Increasingly sophisticated algorithms like deep learning and its hierarchical pattern recognition are regarded as a major force driving the adoption of AI. Software like RStudio[6] and Sentient[7] provide unprecedented opportunities for companies and individuals to develop AI applications.

2. What is status of AI in the region?

2.1 What is the market size and level of investment?

Data on the level of investment of AI in the region is limited. According to McKinsey, corporations invested between $20 billion and $30 billion globally in 2016. This included both internal research and development (R&D) and acquisitions. Tech giants such as Alibaba, Amazon, Baidu, Facebook, and Google account for more than three quarters of total AI investment to date. From 2011 through to February 2017, these companies were behind 29 of 55 major merger and acquisition deals in the United States of America (USA) and 9 of 10 major deals in China[8].

According to Tractica, globally, revenue generated from the direct and indirect application of AI software will grow from $1.4 billion in 2016 to nearly $60 billion by 2025[9]. The International Data Corporation (IDC) estimates that the adoption of cognitive systems and AI across a broad range of industries will drive worldwide revenues to more than $47 billion in 2020[10] [11].

[4] Derived from Growing the Artificial Intelligence Industry in the UK, 2017 and https://singularityhub.com/2016/08/29/7-factors-driving-the-artificial-intelligence-revolution/.
[5] See: http://uk.businessinsider.com/heres-how-much-computing-power-google-deepmind-needed-to-beat-lee-sedol-2016-3
[6] See: https://www.rstudio.com/
[7] See: https://www.sentient.ai/
[8] See: https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Artificial%20Intelligence/Artificial-intelligence-and-Southeast-Asias-future.ashx
[9] See: https://www.tractica.com/newsroom/press-releases/artificial-intelligence-software-revenue-to-reach-59-8-billion-worldwide-by-2025/.
[10] See: http://www.information-age.com/revenue-ai-systems-top-47-billion-2020-123465508/
[11] It is important to note that any estimations of future AI markets need to be considered with caution given the dynamic nature of the industry.

2.2 Which countries are leading the development of AI?

Estimates suggest that China's total investment in AI enterprises reached $2.6 billion in 2016[12]. China's State Council has recently issued guidelines on AI development wherein it is aiming to become a global innovation centre in the field by 2030, with an estimated total output value of the AI industry projected at $147 billion[13]. China Artificial Intelligence Industry Innovation Alliance (CAIIIA) was set up in 2017. The newly formed alliance set a target to incubate 50 AI-enabled products and 40 firms, launch 20 pilot projects, and set up a technology platform in the next three years[14].

Singapore recently announced plans to invest over $100 million in AI over the next five years[15]. In the Republic of Korea, SK Telecom announced in early 2017 that it will invest $4.2 billion in AI[16].

Measured by patents filed, from 2010-14, the USA led AI-related patent applications submitting 15,317 applications. China was second submitting 8,410. During this period, Japan and Republic of Korea submitted 2,071 and 1,533 respectively. India was also among the top 10 countries globally in terms of numbers of patents submitted. In addition, China and India are among the top 10 countries in terms of the number of AI companies[17].

2.3 Who are the leading AI companies?

Several analysts have listed the following global companies in terms of investment in AI: Amazon, Baidu, Facebook, Google, IBM, Microsoft, Tesla Motors and Nvidia[18]. Among these companies, the only company from Asia and the Pacific is Baidu. Baidu have invested $3 billion in AI R&D since 2015[19].

However, the landscape may soon change with the rapid development of AI in the region, especially in China. Apart from Baidu, two Chinese companies Alibaba and Tencent are investing heavily in AI[20]. Alibaba plans to invest $15 billion in R&D labs and hire 100 scientists across the tech nexus of the US, China and Israel over three years starting from 2017[21].

Financial muscle apart, several factors mean these companies will play a leading role in the region in the future. First, they treat AI as long-term investment. Martin Lau, the president of Tencent, recently commented, *"we will be persistent but patient with our AI investment, because we believe it is a long-term initiative and we do not necessarily require our research to generate revenue directly in the short term"*[22]. Second, their strategies for investment will provide access to the latest technologies and top talent. For instance, they have all set up offices in Silicon Valley[23]. Third, they all have access to a large amount of data. As highlighted earlier, big data is essential for AI.

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[12] See: http://www.nasdaq.com/article/an-indepth-look-at-baidus-bidu-artificial-intelligence-aspirations-cm821145
[13] See: http://english.gov.cn/policies/latest_releases/2017/07/20/content_281475742458322.htm
[14] See: http://www.chinadaily.com.cn/business/2017-06/21/content_29833433.htm
[15] See: https://www.cnbc.com/2017/05/03/singapores-national-research-foundation-to-invest-150-million-dollars-in-ai.html
[16] Lachlan Colquhoun, "The road to 5G", Telecom Asia, 7 March 2017, See: http://www.telecomasia.net/content/road-5g.
[17] See: https://asia.nikkei.com/Business/Trends/China-AI-patent-submissions-shoot-up and https://www.economist.com/news/business/21725018-its-deep-pool-data-may-let-it-lead-artificial-intelligence-china-may-match-or-beat-america
[18] See: https://www.forbes.com/sites/moorinsights/2017/01/06/five-things-to-watch-in-ai-and-machine-learning-in-2017/#8ad12455a540
[19] See: https://www.forbes.com/sites/ywang/2017/05/08/inside-baidus-billion-dollar-push-to-become-an-ai-global-leader/#19d0a503516b.
[20] See: https://www.forbes.com/sites/sarahsu/2017/07/03/china-is-investing-heavily-in-artificial-intelligence-and-could-soon-catch-up-to-the-u-s/#77468f1c5384.
[21] See: https://www.ft.com/content/ac3fd8f8-ae5f-11e7-beba-5521c713abf4.
[22] See: https://www.reuters.com/article/us-tencent-results/tencent-to-boost-ai-after-profit-jumps-on-mobile-games-wechat-idUSKCN1AW16J
[23] See: https://www.cnbc.com/2017/08/31/tencent-silicon-valleys-next-big-health-investor.html.

Statistical data are missing in determining which sectors have been most active in applying AI in the region. Nevertheless, analysis of the types of AI companies in China[24], India[25], Japan[26], and Republic of Korea[27] yields a preliminary conclusion that AI has been mainly applied in the following sectors: retail and consumer; technology, communications and entertainment; financial services; and warehousing and logistics.

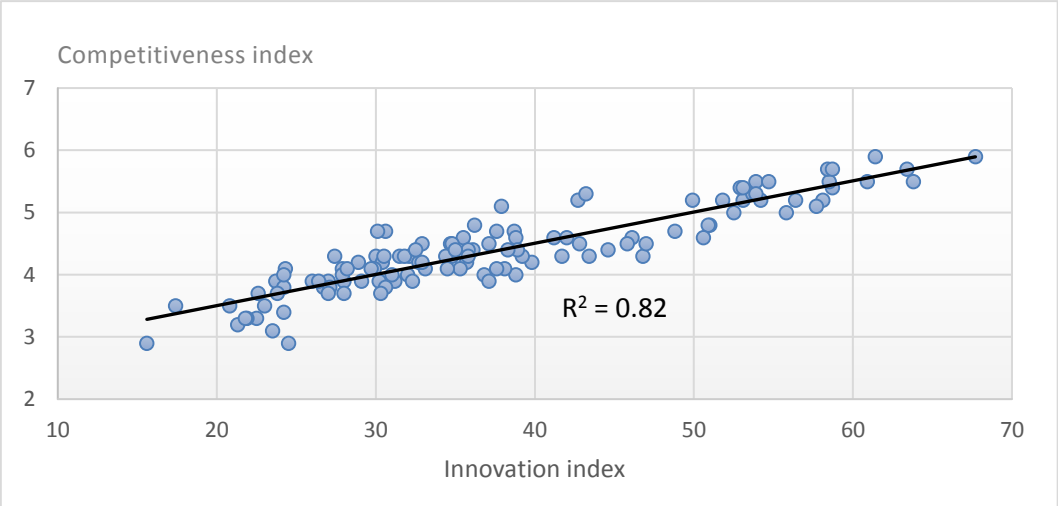
3. Why is AI important for governments in the region?

3.1 What opportunities can AI bring to developing countries?

Strengthening national competitiveness

Recently, the President of the Russian Federation said *"artificial intelligence is the future not only of Russia but of all of mankind. There are huge opportunities, but also threats that are difficult to foresee today. Whoever becomes the leader in this sphere will become the ruler of the world"*[28]. From an economic perspective, in the early 1990s, Michael E. Porter, a professor from Harvard University, pointed out that *"a nation's competitiveness depends on the capacity of its industry to innovate and upgrade"* [29]. This point is well supported by available data. As shown in Figure 1, national competitiveness is highly correlated with national innovation capability. AI, as a leading frontier technology, can potentially accelerating the pace of innovation, enhance the productivity of a country and strengthen national competitiveness.

Figure 1: Correlation between national competitiveness and innovation capability



Source: Prepared by the authors. Data are derived from The Global Competitiveness Report 2016–2017 (https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1) and Global Innovation Index 2017 (https://www.globalinnovationindex.org/). Sample covers 120 countries worldwide.

[24] See: https://www.chinamoneynetwork.com/2017/03/07/here-are-chinas-top-10-ai-companies-challenging-us-tech-leadership
[25] See: http://analyticsindiamag.com/10-startups-india-leading-race-artificial-intelligence-2017/
[26] See: http://www.abh-ace.be/sites/default/files/News/Invisible/artificial_intelligence_in_japan.pdf
[27] See: https://www.rvo.nl/sites/default/files/2016/04/Artificial%20Intelligence%20industry%20in%20South%20Korea.pdf.
[28] See: http://edition.cnn.com/2017/09/01/world/putin-artificial-intelligence-will-rule-world/index.html
[29] See: https://hbr.org/1990/03/the-competitive-advantage-of-nations

Supporting delivery of the Sustainable Development Goals (SDGs)

In principle, AI can be applied in all sectors and industries. Therefore, AI can contribute to achieving all SDGs. A few areas, which are particularly relevant to developing countries in the region, are highlighted below.[30]

- **Healthcare (SDG Goal 3)**

  Developing countries are endemically short of medical workers[31]. AI applications have the potential to fill this gap. In the case of the Ebola virus, machine learning enabled the identification of species that harboured the virus[32]. More recently, AI applications have been developed that substitute and complement highly educated and expensive expertise by analysing medical images[33]. For example, an experiment that tested an AI algorithm for detecting cancer against 21 trained oncologists performed just as well as the doctors[34].

- **Education (SDG Goal 4)**

  Quality education is a key development challenge for many developing countries. A UNESCO study shows that 27.3 million primary school teachers will need to be recruited worldwide, and remarked that trained teachers are in short supply in many countries[35]. While there are currently few applications of AI for education, AI can potentially provide customised teaching[36] and automated assessment of essays[37].

- **Energy (SDG Goal 7)**

  Energy is a cornerstone for sustainable development in the region. Faced with an increasing demand for renewable energy, countries in the region may benefit from AI in hybrid energy system optimisation[38].

- **Decent work (SDG Goal 8)**

  AI-powered automation may replace some repetitive jobs and create new types of AI or IT related jobs. However, as discussed in Section 3.3, AI may also bring downside impacts on employment.

- **Industry, innovation and infrastructure (SDG Goal 9) and responsible consumption and production (SDG Goal 12)**

  As discussed in Section 1, AI is a frontier technology by nature. Adaption of AI will generally bring innovative ways of production and enhance productivity.

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[30] This section largely duplicates a related study by ESCAP titled "State of ICT In Asia and the Pacific 2017: Broadband Divide and Artificial Intelligence".

[31] Hoyler, Marguerite, Samuel RG Finlayson, Craig D. McClain, John G. Meara, and Lars Hagander. "Shortage of doctors, shortage of data: a review of the global surgery, obstetrics, and anaesthesia workforce literature." World journal of surgery 38, no. 2 (2014): 269-280.

[32] See: https://channels.theinnovationenterprise.com/articles/ai-in-developing-countries

[33] See: http://www.itu.int/en/ITU-T/academia/kaleidoscope/2016/Pages/jules-verne-corner.aspx

[34] Esteva, Andre, Brett Kuprel, Roberto A. Novoa, Justin Ko, Susan M. Swetter, Helen M. Blau, and Sebastian Thrun. "Dermatologist-level classification of skin cancer with deep neural networks." Nature 542, no. 7639 (2017): 115-118.

[35] See: http://unesdoc.unesco.org/images/0023/002327/232721E.pdf

[36] Ibid.

[37] Vajjala, S., 2016. Automated assessment of non-native learner essays: Investigating the role of linguistic features. arXiv preprint arXiv:1612.00729.

[38] Seyed Mojib Zahraee, Morteza Khalaji Assadi and Saidur Rahman, "Application of Artificial Intelligence Methods for Hybrid Energy System Optimization", Renewable and Sustainable Energy Reviews, vol. 66 (2016), pp. 617-630.

- **Agriculture (SDG Goals 1, 2, 5, 8, 10 and 12)**

  Another avenue where AI has immense potential for developing countries is in increasing agricultural efficiency. For example, recent advances in image recognition allowed researchers to scan more than 50,000 photos of plans to help identify crop diseases at sites using smartphones with a success rate of over 99%[39].

Transforming public service delivery

AI can enhance public service delivery by assisting civil servants in a variety of ways. For instance, in Japan, AI systems are used to analyse images from a variety of sources to track and reduce littering and to respond to parliamentary enquiries from citizens as examples. Some governments in the region have been taking innovative policy action to utilise emerging technologies in the delivery of public services. In Singapore, the government recently set up a new agency, GovTech, to create an enabling environment for emerging technologies. GovTech's objective is to drive digital transformation across government. It will work with public sector organizations, the ICT industry and citizens to apply technologies such as AI and machine learning to government services[40]. Setting up such agencies should support the evolution of next-generation public services. Moreover, by hiring staff with technology skills, the government is supporting the development of a new wave of civil servants fit for the twenty-first century. The experiences from such initiatives will provide important lessons for other governments.

3.2 What challenges can AI bring to developing countries?

Ethical issues

AI can create new markets and help business and consumers alike become "smarter" and more efficient; however, ethical issues are abound. What rules should dictate the algorithms that decide how much we can borrow or what healthcare we will receive? Should driverless cars prioritise the life of the driver or pedestrian?

Answers to these questions depend on, among others, the way AI algorithms are trained and the quality of data fed into the system. Biased data may yield biased AI learning outcome. In a hypothetical scenario, if all data fed into an AI system show that people from a specific region should not be granted loans, the AI system may make the same decision in the future. More recently, John Giannandrea who leads AI in Google, pointed out that bias, rather than the killer robots, would be the real AI danger. On this point, solutions should be centred on the transparency of data used to support unbiased AI systems[41].

Governments have already begun to tackle such issues. For example, in Germany, the Federal Government has proposed rules for decision-making to promote ethical behaviour by systems guiding crash scenarios for driverless cars. These rules prioritise human life above property damage and do not discriminate between human lives. Although industry is driving advances in AI technology, governments must play a key role in ethical and governance considerations. Member States

[39] *See: https://channels.theinnovationenterprise.com/articles/ai-in-developing-countries*
[40] See http://www.computerweekly.com/news/4504006629/Singapore-launches-department-to-drive-digital-public-services
[41] http://uk.businessinsider.com/killer-robots-biases-artificial-intelligence-ai-2017-10

consensus on standards and ethical principles for technological advancements will be critical to ensure that technological transitions are well-managed.

Balancing privacy and openness of data presents another ethical dilemma. The data made available through the open and big data movements has combined with advancements in computing, machine learning and behavioural economics to fuel the growth of AI. How governments manage data, now and in the future, will be important. Striking the right balance between privacy, ownership and transparency is a difficult task.

A new frontier technology divide

Although billions of people around the world have reaped the benefits of the internet, many billions have been left behind. As ICT infrastructure is the backbone of AI, there is a risk of a new frontier technology divide. For example, the fixed broadband subscriptions per 100 inhabitants in the Asia-Pacific region is still far lower than Europe and North America, and remains below the world's average of 12.4 in 2016. 18 ESCAP member countries continue to have less than 2 broadband subscriptions for the same indicator[42].

The widening gap among sub-regions in Asia and the Pacific is an alarming trend, considering that the widespread introduction of AI and related digital technologies is only possible with broadband infrastructure. While developed countries, with the most expansive and high-speed broadband networks, are embracing and investing in AI at astonishing rates, developing countries are getting left behind.

The "digital divide" has dominated the "ICT for Development" agenda. Governments have a duty to ensure that it doesn't dominate the "Frontier Technology for Development" narrative.

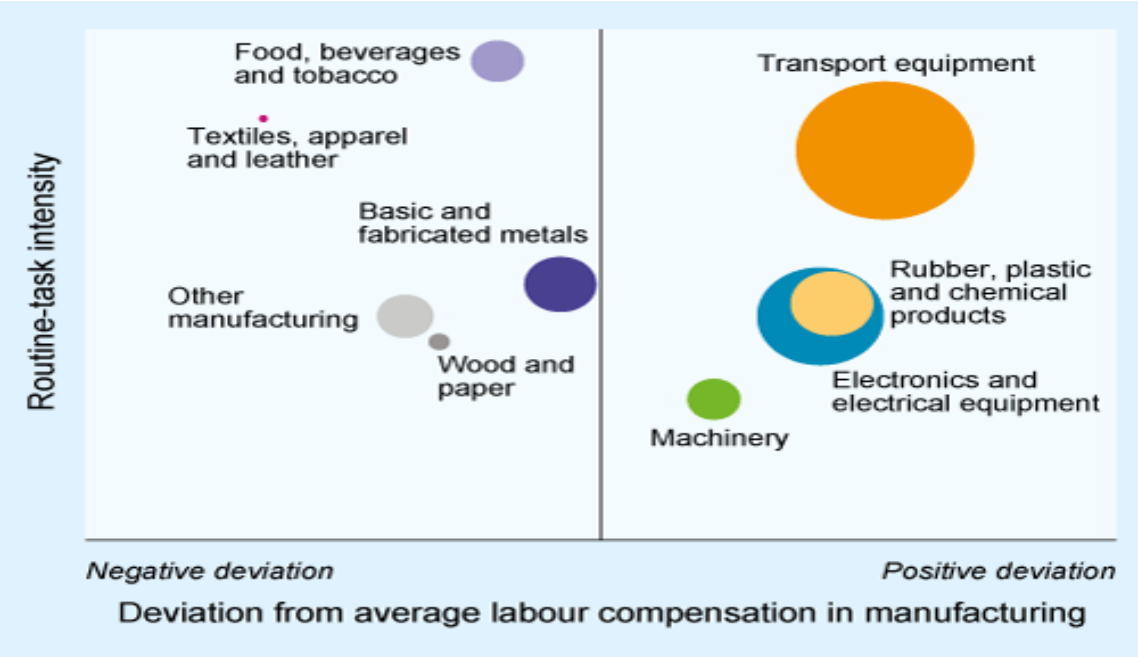
Technological unemployment – a potential concern but certainly not preordained

In theory, widespread adoption of automation or robots may make some jobs redundant. However, two clarifications are essential. First, automation or robots are not the same as AI, which means AI should not be held accountable for all job loss by automation or robotics. Despite numerous forecasts on how automation or robots will replace human labour, a recent UNCTAD report[43] shows that many existing studies mainly focus on the technical feasibility of job displacement while neglecting the factor that what is technically feasible is not always economically profitable (See Figure 2). As a result, existing studies often overestimate the potential adverse effects of robots, especially in developing countries. Indeed, the same UNCTAD report points out that robot deployment has remained very limited.

Second, as discussed in Section 2, AI has been mainly developed and applied a few sectors in several advanced economies. Therefore, AI has had limited impacts on job markets in many developing countries. Even in AI-advanced countries, according to a survey conducted by McKinsey of 3,000 AI-aware C-level executives across 10 countries and 14 sectors, *"the majority of firms did not expect AI to significantly reduce the size of their workforce".* Ultimately, decisions on the adoption of AI technology often hinge on cost-benefits analysis (See Box 2).

[42] ESCAP, State of ICT In Asia And the Pacific 2016, Uncovering the Widening Broadband Divide, Technical Paper, http://www.unescap.org/sites/default/files/State%20of%20ICT%20in%20Asia%20and%20the%20Pacific%202016.pdf
[43] UNCTAD (2017), Trade and Development Report 2017, also see http://voxeu.org/article/industrial-robots-and-inclusive-growth.

Figure 2: Proximate relationship between technical and economic feasibility of routine task automation and estimated stock of industrial robots by manufacturing sector



Source: UNCTAD, 2017, Trade and Development Report 2017.

4. What are the AI policy priorities for governments?

History shows that policy matters. As an example, the modern car was invented in England. During the technology's emergence, England enacted the Red Flag Act. This required three people at all times to operate the vehicle: 1) a driver, 2) a person to fuel up the vehicle and 3) someone to stand in front of the car and waive a red flag. To protect citizens, a 2-mph speed limit was also enforced in urban areas. These regulations stymied the fledgling automotive industry in England, while in the USA, Henry Ford began building cars in 1896 and launched his company in 1903. Free from such regulatory handicaps, the USA gained the advantage in the emerging motor car sector.

It is well recognised that development of AI has been largely market-driven to date. However, government policy will have a crucial role to provide a direction for industry and to deliver on the ambitions of the 2030 Agenda.

Governments in the Asia-Pacific region have been at the forefront of developing and implementing innovative policies and strategies for AI development. In July 2017, China published a comprehensive AI development policy with the overarching goal to make the country *"the front-runner and global innovation centre in AI"* by 2030[44]. In Singapore, with an investment of over $100 million for the next five years, AI.SG was set up in 2017 to bring together government agencies, universities and institutes, investors, industry, and start-ups to advance AI research, development, and practical use in Singapore[45]. The Japanese government recently announced that it will set up an AI panel with the aim to design a road map for development and commercialisation of AI. In addition, the Ministry of Science, ICT and Future Planning (MSIP) of the Republic of Korea has laid out the "Artificial

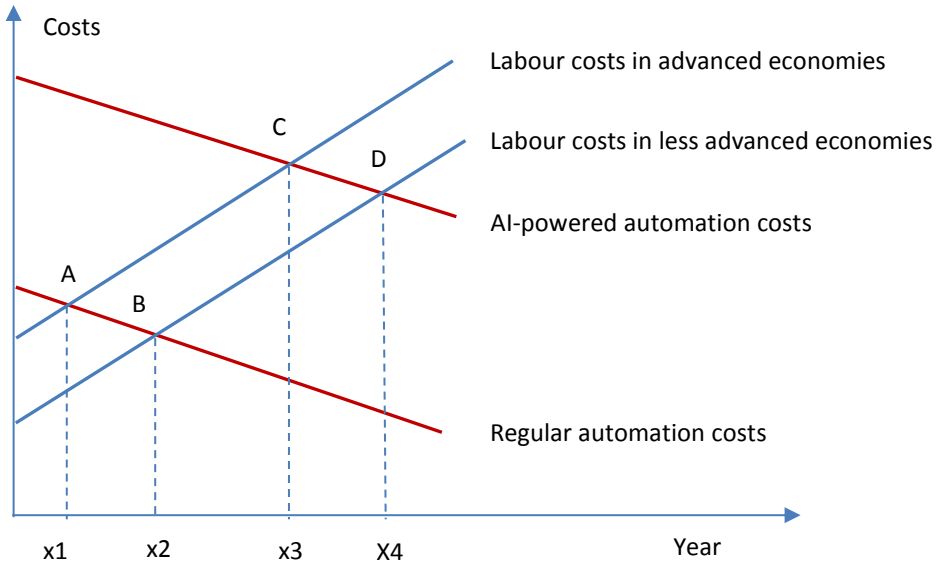
[44] See: http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm (In Chinese).
[45] See: https://www.techinasia.com/singapore-aisg-startups.

Intelligence Information Industry Development Strategy", which aims to strengthen the foundation for AI growth[46]. In late 2016, the government published their "Intelligence Information Society 4th Industrial Revolution Medium- to Long-term Comprehensive Response Plan"[47].

Box 2. Options for replacing labour with automation from a cost perspective

Existing studies often use AI, automation and robotics interchangeably. However, they are not the same, although application of AI, automation and robotics can be interwoven. Robotic process automation – or RPA in short – involves the production of automation with the help of software. Robotic process automation differs from AI in the sense that software robots must always be provided with instructions, because they themselves are not intelligent — at least, not yet[48]. Such differentiation is important because current and projected job displacements will be driven by automation rather than AI. AI-driven automation has been gradually applied. However, such automation is often very expensive, and has been mainly used in high-tech and expensive products.

The figure in this box provides a schematic analysis of costs for the adoption of AI-powered automation or labour. Assuming labour costs keep rising while automation costs keep decreasing. The equilibrium is first achieved in more advanced economies between regular automation and labour (point A). This means, from a cost perspective, advanced economies are more likely to adopt regular automation after this point. The equilibrium is achieved later in a less developed country (point B). Given the high costs, AI-powered automation tends to be adopted later than regular automation (point A vs. point C, or Point B vs. point D). Again, advanced economies tend to adopt AI-powered automation earlier than less advanced economies.



[46] See: http://blogs.worldbank.org/ic4d/what-korea-s-strategy-manage-implications-artificial-intelligence
[47] See: http://english.msip.go.kr/english/msipContents/contentsView.do?cateId=msse44&artId=1325782
[48] *See: https://www.arcusys.com/blog/the-tools-of-the-future-today-what-is-robotic-process-automation-artificial-intelligence-and-machine-learning*

4.1 What are the challenges for the development of effective AI policies?

How AI will unfold in the future remains unknown. There seems to be consensus that in the long term, the impacts of AI could be profound. In addition, the following challenges for assessing the social, economic and environmental impacts of AI make it difficult to develop effective AI policies.

Lack of data for developing countries (including those located in the ESCAP region)

A recent study by DESA highlighted that *"very little is known about the potential impact of new technologies on low-income countries"*[49]. Existing studies are mainly focused on large economies such as USA, European Union and China. In contrast, little attention has been given to developing countries. Furthermore, there is little evidence to show that data and information on AI in developing countries has been collected.

Inconsistent forecasting

Forecasting on the impacts of AI are inconsistent and not only in the Asia-Pacific region. For instance, in 2013, researchers at Oxford University estimated that almost half of USA occupations were likely to be automated[50]. In contrast, McKinsey in 2016, after analysing 830 occupations, concluded that just 5% of them could be completely automated[51].

Lack of public debate

How AI will unfold in the future remains uncertain. It is essential for all stakeholders of society to have an opportunity to understand the topic and participate in the discussion. However, public debate in Asia and the Pacific is much less than similar activities in Europe and North America. For instance, the first congressional hearing on AI in the USA in 2016 and the first session of the House of Lords' select committee on AI in the United Kingdom in 2017 are accessible to the public[52].

Lack of human capacity, especially government officials and policymakers, in developing AI policy

Government officials and policymakers are often not AI technical experts, they do not have to be. However, they need adequate knowledge of AI so that effective policies can be formulated. In developing countries in the region, capacities of government officials need to be enhanced.

Lack of more detailed classification of AI

In many existing studies, AI, automation and robotics have been used interchangeably. Nevertheless, a classification of AI, automation and robotics has important policy implications. For instance, automation, which is not necessarily AI-empowered, may have more direct impacts on manufacturing industries in developing countries than AI.

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[49] See: https://www.un.org/development/desa/dpad/publication/frontier-issues-artificial-intelligence-and-other-technologies-will-define-the-future-of-jobs-and-incomes/.

[50] Frey, C. and Osborne, M. (2013), The Future of Employment: How susceptible are jobs to computerisation?, http://www.oxfordmartin.ox.ac.uk/publications/view/1314.

[51] https://qz.com/904285/the-optimists-guide-to-the-robot-apocalypse/

[52] See https://www.youtube.com/watch?v=fl-uYVnsEKc and https://www.youtube.com/watch?v=wDU-fnXIVos&feature=youtu.be

4.2 What factors constitute an effective AI policy?

Although AI is a frontier policy agenda, concerns regarding the societal implications of emerging technologies are nothing new. A key point to note for policymakers is that there are many lessons to be learnt from past policies to address emerging technologies. In this regard, it will be important for policymakers to engage historians, not just futurists. It will be critical to learn from the past as we shape the future of frontier technologies.

Education and skills

While the labour displacement effects of AI are still an unknown quantity, it would be prudent for governments to build a workforce fit for the future, whatever that may bring. Some directions to consider include: a greater emphasis on entrepreneurship training to develop job creators as well as job seekers, adult education, life-long learning and reskilling to deal with current and future technological transitions. Education must also instil new expectations about work and the marketplace for jobs. This will require innovative education policies such as those promoted by the Government of Singapore. One such policy offers adults personal accounts which they can use to buy training, and another uses tax incentives to encourage firms to invest more in their lower paid workers. In addition, governments should strengthen social protection systems to protect the workers that are vulnerable to losing their jobs. For instance, Finland has become the first country in Europe to pay its unemployed citizens a basic monthly income, in a radical pilot project aimed at reducing poverty and joblessness. Such forward-thinking policies can support a strategy to facilitate redeployment, not unemployment if it occurs.

Adaptive and anticipatory regulation

To avoid hindering the development of AI, regulatory processes need to become adaptive and anticipatory. However, enabling regulation for innovation is difficult to formulate and as such, innovations in regulation processes are urgently required. The Financial Services Authority in the UK has experimented with innovative regulations. For example, in the field of financial technology (FinTech) their Sandbox policy allows businesses to test out innovative financial services without incurring all the normal regulatory consequences.

Effective regulation should allow innovation to flourish while still safeguarding society and the environment. Balancing these demands will be an important government agenda as AI evolves, and one that will require sharing effective practices and innovative approaches between governments.

Anticipatory regulation may provide a solution in developing AI. It emphasises that policy needs to support the development of emerging technologies while also allowing for faster responses to ensure that the public aren't exploited and that new dangers are averted[53]. Certainly, the idea of applying anticipatory regulation to the AI industry is new and its effectiveness needs to be tested in practice.

[53] See: http://www.nesta.org.uk/blog/anticipatory-regulation-10-ways-governments-can-better-keep-fast-changing-industries.

Responsible AI development requires responsible businesses

As the predominant investor in AI, the private sector will shape how AI impacts the economy, society and the environment. However, to create positive impact on these three dimensions of sustainable development, corporations need to move beyond the concept of corporate social responsibility (CSR) and redefine their objective, and associated measures of success, as creating "shared value". Shared value is not CSR. It measures value across the three dimensions of sustainable development at the core of business strategy. To further promote shared value, policy makers need to create the right incentives so these values move from CSR departments to the boardrooms.

Building trust between stakeholders

As we enter the information age, it is increasingly clear that data is a valuable currency. There is an abundance of data out there that could support our peace, security and development efforts. Government-owned satellites, telecommunications multinationals, social media start-ups, all have real-time information at their fingertips. In this data revolution, technology is not the problem. Trust between governments, private sector and citizens is the critical point. A recent survey[54] conducted by the Omidyar Network in sixty countries found that within the sample:

1. The scale of global distrust is enormous with 2 out 3 respondents having no trust in the private sector and governments with content of their phone or online conversations.
2. Trust drops sharply by 18% between those with primary education and those with secondary education or higher. An average of 58% of respondents with a primary school education reported data-trust, while only 40% of individuals with advanced degrees indicated data-trust.
3. Finally, the data shows a trend that trust diminishes as national income increases (Note: This does not reflect the income level of individual respondents, rather the income level of the countries in which they reside).

These findings raise questions in our pursuit of the SDGs. As we strive towards education for all and raising incomes, will this come at the cost of trust between citizens, governments and the private sector? The UN should play a convening role in building trust amongst these stakeholders to utilise this information for peace, security and development while safeguarding privacy. While this is a complex and difficult issue to address, we cannot shy away as it is crucial to exploiting the opportunities at the nexus of data and frontier technology.

5. Conclusion

In conclusion, AI will have far reaching consequences throughout the region and across the globe. The Asia-Pacific is leading from the front and is forecast to be the prominent market of the future. This prominent position, however, means governments need to think carefully about the role and scope of AI in pursuit of sustainable development. Specifically, governments must address the ethical dilemmas, develop a workforce fit for the future, put in place adaptive and anticipatory regulation, incentivise the private sector to act responsibly, and utilise AI to deliver more efficient public service delivery.

[54] See: https://www.omidyar.com/sites/default/files/file_archive/Constituent%20Voices%20Trust%20and%20Privacy.pdf

This will require thoughtful research and policy formulation; cross-government cooperation; inter-governmental knowledge-sharing and consensus-building; and honest, open and regular discussion with the civil society and private sector, specifically technology developers.

However, governments currently lack the necessary coordination and processes to prepare for an AI revolution.[55] Nonetheless, the revolution will come, and the United Nations could play a greater role in helping the region navigate this future.

This paper serves as an initial step towards understanding the status of AI development in the region. In the process of preparing this paper, the study team faced difficulty in collecting data and information. This is consistent with another UN study which states that *"very little is known about the potential impact of modern technologies on low-income countries"*[56]. Accordingly, the purposes of this paper are not only to present key findings and conclusions but also to inspire and engage policy makers, experts and the public to debate the topic, so that AI can be better understood in the region and the potential benefits from applying AI can be better explored.

6. Role of ESCAP

ESCAP will support its members to navigate the inevitable technologically-driven future that we face in the following ways:

- As a regional think tank, ESCAP has and will continue to conduct research on frontier technology.
- Furthermore, ESCAP can support its members to develop appropriate policies by supporting knowledge-sharing between the growing expertise in the region.
- ESCAP will serve as a platform for discussion, debate and consensus-building through our regional inter-governmental and multi-stakeholder platforms.
- ESCAP will also provide the link between the regional and the global to share knowledge on the emerging movement on frontier technology in the region.

[55] See https://www.centreforpublicimpact.org/government-future-ai/
[56] See: https://www.un.org/development/desa/dpad/publication/frontier-issues-artificial-intelligence-and-other-technologies-will-define-the-future-of-jobs-and-incomes/.