TRANSFORMATION OF WORK IN ASIA-PACIFIC IN THE 21ST CENTURY

HKUST BUSINESS SCHOOL 香港科大商學院
WORLD CLASS IN ASIA

APRU

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Contents

Preface

The unique strengths of this book lie in the diversity of national contexts from which the authors write and the refining of their insights into policy recommendations.

The rolling disruptive effects of AI on existing jobs and living conditions are seen as inevitable. Recommendations are made to minimize negative impacts and enhance the benefits of technological innovation, to address ethical issues, to prepare and protect the workforce, to transform the education system and to reduce inequality.

The popular imagination envisages a dystopian world where the impoverished majority of the population is kept under control by an elite using the tools of artificial intelligence. These studies show that this need not become reality if appropriate policies are adopted ranging from a universal basic income and universal health care to encouraging entrepreneurship and developing an ecosystem which helps both small and large firms make the technical transition.

In partnering with *Google* on this project, APRU seeks to ensure that the research of our member universities is widely disseminated and made available to policymakers, business leaders, international organizations and the community at large.

Already, the findings of this project have been included in the *State of the Region Report* published by the Pacific Economic Cooperation Council (PECC) in November 2018.

An APRU student case competition in partnership with *The New York Times* in October 2018 was won by a team which had several similar recommendations in their policy brief to ensure that social goals are built into AI research and development and that the benefits are shared equitably. Marcus Wong, Jaffar Al-Shammery Bui and Tomi Ozawa from The University of Auckland recommended tax incentives for companies to manage the effects on vulnerable workers, to implement a universal basic income scheme and to connect researchers, regulators and businesses through open communications systems.

This work on AI reinforces the role of universities in identifying and standing for the common good in an era of rapid change which could easily spin into social turmoil and dislocation.

APRU's Digital Economy Initiative, established and driven forward by Keio University in Tokyo, was the progenitor of our work on AI. Beginning in 2014, it brought together academics from many disciplines, IT industry leaders and government policymakers each year to focus on the implications of technological developments for the economy. This network provided the platform for APRU's move to examine AI's effects on society.

In addition, it fed into our work to bring the social sciences and humanities into deeper collaboration with the STEM disciplines in understanding these effects. Models for this collaboration along with case studies form the greater part of the APRU report *Transformative Solutions to Asia-Pacific Challenges* published in October last year.

I wish to thank Dean Kar Yan Tam of HKUST Business School, for his highly effective leadership of this latest project which advances further our contribution to research and public policy. I thank also the individual authors for their engagement with the process of shaping the project.

We will work with our partners to disseminate this study and its recommendations as widely as possible as a significant contribution to the public policy process in the Asia-Pacific region.

Christopher Tremewan
Secretary General
APRU

Introduction

Digital automation is transforming the world with unprecedented scope and speed. Advances in artificial intelligence, robotics, big data, and the Internet of Things are continually reshaping the global economic landscape, and their impacts are felt at all levels of society. The boundary between the physical and digital world is becoming blurred. Digital automation permeates every stage of the value chain and crosses organizational boundaries.

While societies have benefited from the scientific and economic progress resulting from digital automation, there have also been many challenges that, if not addressed, will create social and economic problems that overshadow the benefits of automation. Two key challenges are the potential dislocation of the workforce as a result of automation and the urgent need to nurture talent to realize the many opportunities that automation brings. Compared with previous industrial revolutions, whose full economic impact took many decades to unfold, current advances in automation will proceed at a much faster pace and with a far broader scope due to globalization and ubiquitous communication networks connecting human and physical subjects. The diffusion of innovations, including cost-cutting automation tools, will proceed at unprecedented speed, disrupting current business practices and the supporting workforce.

The future of work has become an important research topic in recent years. Predictions of job losses and new job opportunities continue to make media headlines. These predictions span a wide range: according to one estimate, 47% of jobs in the US will be replaced in the next two decades (Frey and Osborne, 2013), while another, more modest estimate claims that 9% of jobs are at risk of automation (Arntz et al., 2016). Although there is an ongoing debate about the best methodology for such estimates, researchers agree that the impact of automation is significant and that the government can play a vital role in facilitating the transition for both the economy and the affected workforce.

So far, most of these studies have focused on developed countries in the Western world. Few have focused on the impact of automation in the Asia Pacific region. This region is home to 4.3 billion people, representing 60% of the world's population. It is one of the world's most dynamic regions and accounts for more than 50% of global economic growth (International Monetary Fund, 2018). While the region's economic trajectory is on the rise, many countries in the region face a number of challenges, including aging, declining productivity, and the uncertain outlook of global trade. These challenges, coupled with the exogenous shock of digital automation and its sweeping impacts on the global economic landscape, could derail the developing trajectory of countries in the region. Manufacturing is key to many developing countries in the region and the industry is driven by a low-cost, low-skilled labor workforce. Automation will challenge the wage advantage of developing countries and transform the nature of manufacturing, which may lead to a large-scale reshoring of production back to developed countries. The recipe for economic success for many Asia Pacific economies since the 1980s is no longer viable, and new growth models must be developed.

While there are challenges ahead, automation creates opportunities for developing countries to circumvent older generations of technology and directly adopt the latest technology. For example, hundreds of millions of citizens in developing countries in the region are directly connected to the telephone network via mobile phones instead of land lines, which are still common in many developed countries. The fact that Asian economies are at the forefront of digitalization presents opportunities for policymakers to devise novel approaches to address the challenges of automation.

Countries in the region feature very different social-economic demographics, which will react to digital automation in very different ways. As such, a government's choice of policy instruments will vary depending on its country's specific social and economic circumstances. The likelihood that innovations will gradually replace human labor as a production factor is real. It is prudent for policymakers to prepare for the turbulence ahead. They need to reckon with the risk and assess its impact on the labor market. As many stakeholders will be affected, preparing the public by appropriately framing the issue and ensuring that it is on the political agenda is a first step in the planning process. Constituents need to be consulted and their views incorporated into policy deliberations.

With this study, we hope to open up a dialogue enabling policymakers, leading thinkers, and researchers to exchange ideas and collaborate on effective solutions to the challenges presented by the rapid digitalization of our societies. We highlight issues facing Asia Pacific countries and make policy recommendations for coping with the social and economic challenges arising from the worldwide adoption of digital automation. Given the scope of this project, we cannot provide a comprehensive analysis of the situation facing each country. In particular, India and China, which are very geographically and economically diverse, deserve dedicated studies of their own. However, many issues facing the region are relevant and applicable to all countries there, even if they are in different stages of development. The impact of digital automation is addressed in the seven chapters of this study. Each presents a single perspective, and complements the other chapters; together, they offer a richly holistic view even as they draw attention to specific issues and their resolutions.

The first two chapters chart the way to a deeper understanding of digital transformation by providing overviews of technological changes and their impacts. Chapter 1 introduces and explains the concept of digital automation through a careful examination of its characteristics and trends. By discussing its impacts with a specific focus on the Asia Pacific region, the chapter provides an overview of how digital transformation affects society in terms of jobs, quality of life, and the public sector. Chapter 2 further strengthens the notion of digital automation by providing a historical survey of technological change, identifying key consequences of disruptive technologies in the past, and highlighting the potential impacts and consequences of emerging technologies. Using data and analysis from the Asia Pacific region, Chapter 2 draws our attention to similarities and differences between Eastern and Western economies across different time spans, and furnishes insights into the strategies used by governments within this region for dealing with technology.

The next two chapters illustrate what automated societies will look like. Chapter 3 looks at the social benefits of automation and how to realize them by creating relevant policies. The chapter focuses on Japan as an example, and uses a series of scenarios to examine the associated social benefits and risks. The chapter also discusses the role of and requirements for technology assessment, options for technology assessment frameworks, and frameworks at national and global levels. Chapter 4 examines the relationship between automation and organizational structure by focusing on the role of a manager in the future. We learn about the new skills and business values that future workers will require, a shift that will also have an impact on our way of life and cultural values.

A country's adoption rate for new technology differs based on economic factors, including size, wealth, natural resources, and manpower. As each economy has its own strengths and constraints, each also faces different challenges and limitations. Chapters 5 and 6 look at the relationship between automation and jobs and at the resulting economic impacts. Chapter 5 focuses on the Philippines to look at automation from a developing country's perspective, while Chapter 6 uses Singapore to illustrate the issues from a developed country's perspective. In Chapter 5, the Philippines' potential for adopting new technologies is assessed based on the case of the country's information technology and business process outsourcing sector; inferences are then drawn to other developing economies. The chapter also makes recommendations that aim to help developing countries overcome barriers to automation. In Chapter 6, we develop an in-depth understanding of the potential challenges faced by Singapore, a much more competitive economy in terms of technological adoption. The important relationship between automation and the education of the workforce is discussed. Like pieces of a puzzle, automation and education are interlinked; they form the basis of a successful economy in combination with several other factors. The chapter makes a number of recommendations reflecting this key linkage.

In the closing chapter, we identify and analyze several major policy implications and propose a series of recommendations that span important areas such as education, health, immigration, innovation and entrepreneurship, and labor. These recommendations address the most crucial issues governments face as they attempt to create economies that will succeed in the fully digitalized future.

More work need to be done to understand the challenges facing Asia Pacific countries and to formulate effective policy responses to the transformational changes brought about by digital automation. We hope this research serves as a starting point for an ongoing dialogue between policymakers and stakeholders on this important topic. Here, I would like to express my deepest gratitude to the Association of Pacific Rim Universities (APRU) for its support throughout the project. My sincere thanks and appreciation to the authors of the six chapters: Prof. Jungwoo Lee, Prof. M. Jae Moon, Prof. Sunghoon Kim, Prof. Stephen Frenkel, Prof. Hideaki Shiroyama, Prof. Namgyoo K. Park, Prof. Jikyeong Kang, Prof. Jamil Paolo S. Francisco, and Dr. Faizal Bin Yahya. Their in-depth knowledge and experience have enormously benefited our study. Special thanks go to Christina Schönleber of the APRU and Jacqueline Hui of HKUST Business School for their strong administrative assistance and support.

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CHAPTER 1

Coming Age of Digital Automation: Backgrounds and Prospects

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Coming Age of Digital Automation: Backgrounds and Prospects

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"Finally, intelligent machines will take care of our chores, such as driving, cooking, cleaning, dishwashing and laundry, giving us back our most valuable resource — our time…Taking care of our chores and automating manufacturing, of course, will mean a total disruption of patterns of work and employment. Some estimate as many as 40 percent of current jobs will be lost to intelligent machines."

Kai-Fu Lee
Venture Capitalist, 2018

Introduction

Automation-using technologies have replaced human muscles and brains for centuries if not throughout human history. Humans have been keen to automate tasks and displace humans with technological contrivances, whether by augmenting or replacing human efforts, since the advent of civilization. Thus, moving humans themselves onto easier, creative and/or meaningful tasks has been a paramount goal for most technology development. The invention of tools and contrivances for automation has thrived throughout the history of humankind.

The Industrial Revolution was driven by the advancement of energy matter transfer technology, signified by the steam engine, and was interspersed with ingenious contrivances devised to automate heavy lifting and mundane tasks, along with the invention of various control mechanisms. Automation was the main focus of industrial technology development (Davenport & Kirby, 2015). Industrial machines were designed and developed to relieve humans of onerous manual labour, such as running looms and cotton gins, and dangerous tasks, such as controlling heavy machinery. In some sense, humans have since continued to claim areas that machines have not.

However, automation entered a new era with the invention of computers. Automation during the Industrial Revolution was limited to analogue and mechanical automation that targeted the routinisation of work processes. Analogue automation aims to mechanise or routinise tasks so that people can conduct their jobs more easily and with less effort. Assembly lines are a typical example of analogue automation. When computers came into our society, computer-based man-machine interfaces were developed to delegate not only heavy lifting and dangerous tasks but also dull and repetitive calculative tasks to machines. The faster number-crunching capabilities of computers took over simple calculative tasks from humans. This is also referred to as automation (Zuboff, 1988) and precedes the informatisation and transformation that follow technological advances.

Since the advent of primitive computing technologies in the 1960s, digital technologies have significantly evolved from standalone number crunchers into intelligent interconnected tools. We are entering a new world of 'digital automation' (Davenport & Kirby, 2015; Genpact, 2018). This is a watershed moment, as computing technologies continue to evolve with the rapid advancement of artificial intelligence (AI), information and communication technologies (ICTs) and informatics, such as big data analytics, which have multiplied the cognitive and analytic powers of machines and have started to replace human capacities (Robinson & Bogen, 2017; Tito, 2017).

Unlike traditional technologies that mainly replaced humans in terms of physical strength and computing capabilities, digital automation is expected to replace the more complicated cognitive and intelligence capacities of human brains, particularly human learning mechanisms. As AI and informatics advance, human beings are increasingly relying on them for data-processing and decision-making activities ranging from screening and sorting documents, such as job applications and legal documents, to analysing and assessing complicated big data from various sources (private and public), areas (medical, environmental, criminal, geographical and socio-economic) and levels (individual, organisational and regional).

With cognitive capacity added to their conventional physical capacity as a result of recent technological breakthroughs in digital automation, robots with AI have started to engage in a much wider range of human activities than ever before. These new developments present

even more opportunities and challenges. For example, self-driving vehicles and drone-based delivery systems are compelling technological innovations that may change the platforms of transportation and delivery services, but they are also expected to jeopardise many human jobs (Manyika et al., 2017). Similarly, IBM's Watson diagnoses diseases faster and more accurately than doctors who have trained for years, which has implications for many jobs in the medical field (IBM, 2018a). Digital automation has also changed the nature of data processing in organisations. For example, human resources departments in big companies are increasingly relying on AI to select candidates for jobs.

Digital automation is expected to transform the public sector at least as much as the private sector, as it can be easily applied to the decision-making processes and delivery of public services (Eggers, Schatsky, & Viechnicki, 2017; Mehr, 2018; Tito, 2017). Governments, which often resist innovation and changing environments, are seeking alternative approaches to more efficient and effective public service innovation by catching up with the latest trends. For example, they are contemplating how to utilise big data and machine learning technology for better decision making and policy implementation. In such circumstances, it is not surprising that digital automation is changing all aspects of society, from industry to daily life. We hope that digital automation incites innovation, favourable opportunities and new challenges, similar to other previously introduced technologies (i.e., automobiles and phones).

We are at a crossroads with digital automation in the sense that its potential largely depends on how we handle the development of technologies and the accompanying social and economic institutions. Large-scale studies of digital automation, focusing on not only technological development but also its implications and potential, must be conducted, as the expected changes and transformations are much larger than those of the Industrial Revolution. Many research projects are actually being developed and launched across developed nations, predicting what changes digital automation will bring, showing how to design digital automation, measuring the impact of digital automation and indicating how to socially and institutionally prepare for it. However, not many studies have focused on digital automation, particularly in the Asia-Pacific region, which may experience different development patterns than the West. Most are latecomers in terms of technology development and also uphold different cultures and thus different attitudes and orientations in different contexts.

Responding to the paucity of comprehensive studies on the impacts of digital automation in the Asia-Pacific region despite the burgeoning discussions on related topics, we offer a general review of the impact of digital automation on the workforce, quality of life, civil society and the government sector of the Asia-Pacific society. This chapter proceeds as follows. First, we define digital automation as a concept and compare it to analogue automation to reveal the distinct characteristics of recent technological breakthroughs. Examining the unique nature and trends of digital automation, we also discuss its impacts in the Asia-Pacific context. We then discuss how digital automation transforms society in terms of jobs, quality of life and the public sector, with a specific focus on the Asia-Pacific region. Finally, we discuss policy implications.

Automation to Digital Automation

The digital transformation of business using digital technologies started decades ago. Interestingly, the term ‘automation’ was used in the early stages of IT adoption, referring to the computerisation of mundane tasks. It has also been used to refer to not only using computers to automate routine clerical tasks, such as the calculation and comparison of numbers and figures, but also the installation of numerically controlled robotics in manufacturing processes, such as in automobile manufacturing floors. This initial conceptualisation of automation has given way to informatisation and transformation in the later stage as more elevated goals of IT utilisation (Zuboff, 1988) with further technical developments.

These technological developments are metaphorically described as the formation of information continents (Lee, 2016): from information islands via information archipelagos (McFarlan, McKenney, & Pyburn, 1983) to information continents. This metaphor of continentalisation weaves the historical development of digital technologies: transitioning from building functional information systems (islands) to connecting these functional systems via network connections for information integration across different functions and organisations (archipelagos) and then forming base platforms of operations (continents) on which new and innovative services are developed. This progression takes advantage of the nature of information synthesis, as information becomes more meaningful and useful when connected with other information. Figure 1 depicts this progression model of technological development along with the accompanying events.

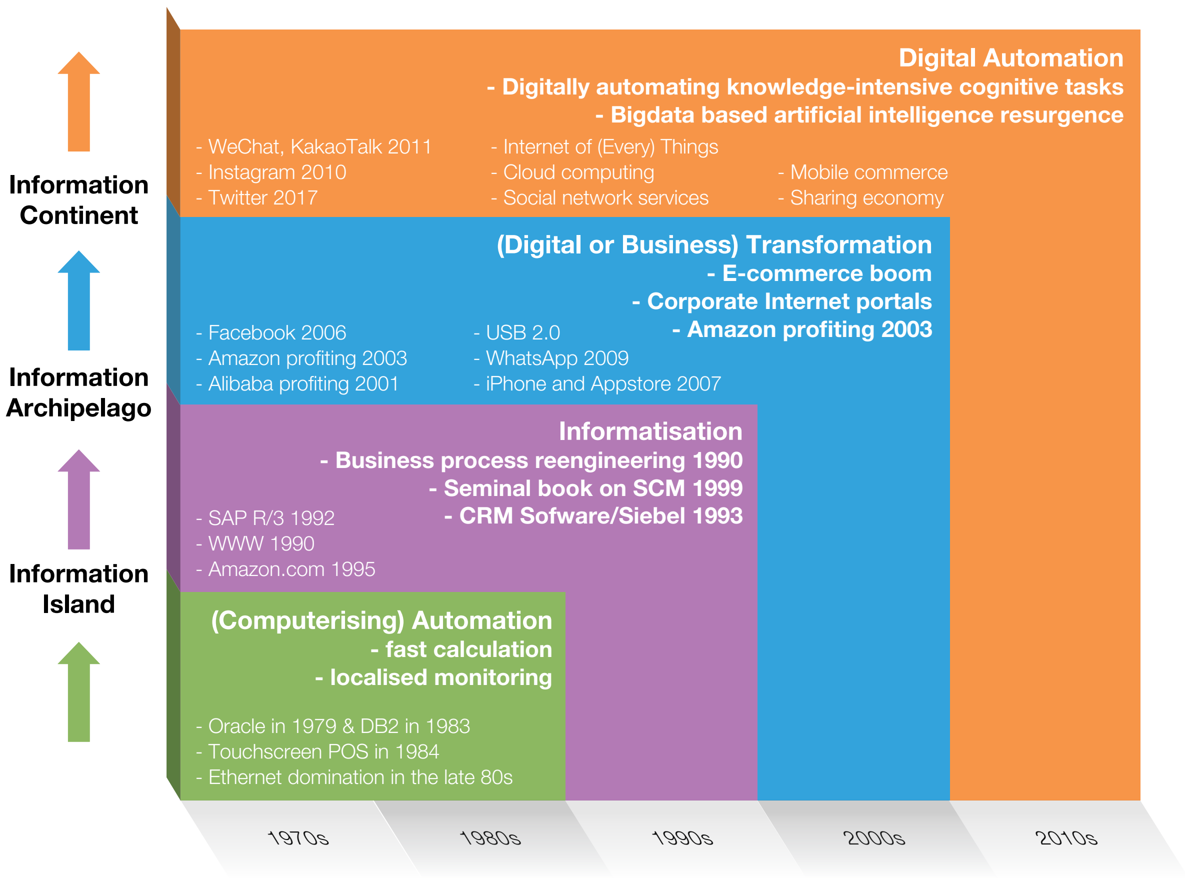
Building information islands for organisations started in the 1980s, when commercial grade database management systems became available. The first commercially available relational database management system – Oracle – was released in 1979 by then Relational Software (now Oracle Corporation). Most modern organisations, both private and public, began to store their mundane daily transactional data and critical and strategic information, building information islands for organisations.

In the 1990s, with the advance of network technologies and faster database management systems, these islands began to be interconnected within and beyond organisational boundaries, aiming to realise the benefit of information integration. Electronic data interchange coalitions were formed and international standards for data exchange were developed. The re-engineering of business processes reflecting the capabilities provided by computers and networks became a very big fad among businesses and organisations. Installing corporate databases along with redesigned business processes called for new higher-level tech positions and executives, such as Chief Information Officer and Chief Digital Officer.

Thus, digital transformation refers to the ultimate goal of business process reengineering, which may lead to the transformation of businesses themselves into new ventures using new business models (Matt, Hess, & Benlian, 2015). In some sense, most IT consultants have proclaimed that digital transformation is about not only automating current processes to replace paper or people, but also creating and providing new value to customers and enterprises (Berman, 2012). It is expected to create new opportunities and new value for customers and businesses.

Coming into the 21st century, the Internet proliferated, providing a common playground for interfacing platforms of different computing technologies. With the commercialisation of Internet technology, businesses have embraced electronic commerce and electronic business as critical components of their business operations beyond the business process reengineering fad (Turban, King, Lee, & Viehland, 2002). Most consulting services develop and present an e-commerce transition model, starting with a simple on-line presence and transactions on-line via the integration of data and processes and leading to a complete transformation into a new realm beyond operation efficiency. In this context, the term 'digital (business) transformation' has evolved from designating operational optimisation, such as automation, into running businesses differently and reinventing business designs using computing and communication technologies with the Internet as a new forefront of the business.

Figure 1: Progression Towards Digital Automation
Adapted and Enhanced by Jungwoo Lee from Lee (2016)



Source: Jungwoo Lee from Lee (2016)

Movements to interconnect systems all converged onto the Internet. All of the hassles that each system would endure with the proprietary format of data and applications were eliminated as most systems started to talk Internet language. Data could be transferred and read without going through 'porting' processes (Goda & Kitsuregawa, 2012). This continentalisation of information introduced new ideas for business operations and the invention of novel business models that could only be realised on these information continents, not on the information islands or archipelagos (Lee, 2016). We now live in a world of these continental platforms, which are composed of ready-made module-based application programming interfaces with standardised databases (Smedlund, 2012). With these platforms emerging, information technologies are reaching a different level of maturity. On these platforms, new integration-based technologies of which we only once dreamed are now feasible.

For example, cloud computing is based on the idea of shared system resources and services that can be rapidly configured and provisioned over the Internet (Armbrust et al., 2010). It relies on large-scale resource sharing only made feasible on information continents. The Internet of Things (IoT) is a connected network of physical devices and machines. It is predicted that 30 billion devices will be connected by 2020 using IoT technology (Da Xu, He, & Li, 2014). This technology would not be feasible without information continents, on which information is readily exchanged and interconnected. Big data analytics, by definition, assumes that data communicate without difficulty. Social networks are platforms on which different socialising services are provided. Mobile computing also assumes the intervening platforms for different services.

These technologies once existed only as a figment of our imagination. All of these concepts are now realisable only because of the readily available information on these information continents. In some sense, the recent resurgence of AI is also largely dependent on the convergence of available big data and the advancement of fast graphics processing units. Deep learning using artificial neural networks, which had been standstill since its initial conceptualisation in 1986, was recently inoculated with a hardware boost from faster graphics processing units and large amounts of visual data made available on the web.

Recently, the growing capabilities of AI combined with the decreasing cost of relatively mature IT, such as cloud computing, the IoT and big data analytics, have led to claims that we are entering a new machine age (Brynjolfsson & McAfee, 2014). The effects of this new machine age may far surpass those of the previous wave of mechanisation, routinisation, (analogue) automation, informatisation and (digital) transformation (Bundy, 2017; West & Allen, 2018). Hence, the term 'digital automation' has been coined, combining digitalisation and automation and signifying the role of enhanced AI, as presented in the last phase in Figure 1.

Examples of AI infiltration into knowledge-intensive tasks are abundant. In 2015, The New York Times implemented its experimental AI project, known as Editor (Underwood, 2018). By searching through data in real time and extracting information based on requested categories, such as events, people, locations and dates, Editor can make information more accessible by simplifying the research process and providing fast and accurate fact checking. Furthermore, the Washington Post is experimenting with automated news writing using Heliograf (Latar, 2018). The Rio Olympic Games in 2016 were mostly covered by articles automatically written by Heliograf, which generated news stories by analysing data about the games as they emerged.

Such robots with AI capabilities may lead to the highest level of productivity in not only manual routine calculation tasks, but also intelligent tasks such as information searching, collection and integration with the help of big data analytics in integrated clouds of information. Robotics, in general, has focused on developing numerically controlled machines installed on manufacturing plants. Now, the integrated availability of data across domains allows people to develop things such as chatbots, which mimic human responses in service inquiries.

Of course, these technological breakthroughs also raise a number of concerns about their possible negative impacts on society (European Commission, 2012). As shown in the Luddite movement after the Industrial Revolution and the Blue-Ribbon National Commission on Technology, Automation, and Economic Progress launched by President Johnson in 1964, anxiety over the replacement of human jobs by machines remains an important agenda in society (Autor, 2015). Whether the positive social impacts of new technologies outweigh their negative counterparts by enhancing overall productivity and creating new businesses, new jobs and new opportunities has been long debated (Arntz, Gregory, & Zierahn, 2016; Autor, 2015).

An Organising Framework for Digital Automation Technologies

The digital automation that we encounter now incorporates new and more advanced tools dealing with intelligence, providing grounds for new conceptualisations of actual AI applications (IBM, 2018b). These are designed to not only improve employee productivity, but also enhance decision making and optimise systems in real time, thus replacing or augmenting human decision making. As a result, digital automation may streamline functions that previously seemed impossible to automate and revise such streamlining in real time without human intervention. In this regard, across different domains of business, from patient care to customer service, corporations are moving from touch-based manual processes to digitalised agile operations, hence the term 'digital automation'.

Thus, in this digital automation that utilises advanced and mature IT, such as the IoT and cloud computing with real-time big data analytics, the scope has expanded from handling the rote automation of repetitive and mundane information tasks to entertaining and supporting a broader range of work styles and scenarios, including knowledge-intensive work (Genpact, 2018). In addition, it includes learning capability to do more than prescribed and actively implementing these decisions.

Characteristics of Digital Automation (vs. Analogue Automation)

Traditional analogue automation is known to 'dumb people down', as indicated by many Charlie Chaplin movies. As analogue automation depends on mechanically interconnected parts and operations, it was designed to dehumanise work, thus treating humans as the components and parts of these operations. In conducting these routinised mundane tasks, humans are supposed to follow machines' operations within pre-specified timings and under other guidelines when performing mundane routinised tasks.

As digital automation in this report maintains the convergence of advanced IT, such as AI, with the automation of higher level of intellectual work, digital automation is geared towards (at least, supposedly) returning humans into the natural state before the industrial and computer revolutions (Kolbjørnsrud, Amico, & Thomas, 2016). For example, hands-free interaction between a service provider and recipient is more of a natural state of customer service rather than a provider that constantly types and asks questions, as what happens in ordinary hospitals these days.

Take for example a nurse's clipboard, used for bedside patient monitoring in hospitals. Simply replacing the paper forms with tablet devices is not in itself digitisation. Of course, there are benefits in doing this, such as faster and more accurate data entry into the electronic health record system than could be achieved with manual transcription. But what if we redesigned the work using smart machines and the Internet of Things? Machines can do most of the monitoring, data collection, and incident reporting, leaving nurses to do things only humans do well, like touch, talk, observe and empathise. The machine can monitor patient vital signs continuously, potentially alerting the nurse to a problem sooner than might otherwise have occurred with only periodic checks. The end result is a better outcome for the patient – and the nurse (Moore, 2015).

In this regard, digital automation is different from traditional automation in the sense that it may introduce self-learning and self-correcting mechanisms. AI capability along with big data analytics may enable machines to make decisions, especially in dangerous situations to prevent accidents from happening. In business situations, this capability may be used to prevent critical losses of various resources. This may refer to the somewhat negative feedback side of digital automation, but it may be implemented on the positive feedback side in which spontaneous decisions are needed to accommodate contextual changes, such as accommodating reasonable customer complaints, which may not have been stipulated in business manuals, spontaneously.

Developmental Stages of Digital Automation

How digital automation technologies will further evolve and how they will influence industries and societies in the future remain unclear. In a recent report, Hawksworth and Berriman (2018) presented three different phases of digital automation: the algorithm wave, the augmentation wave and the autonomy wave (Table 1).

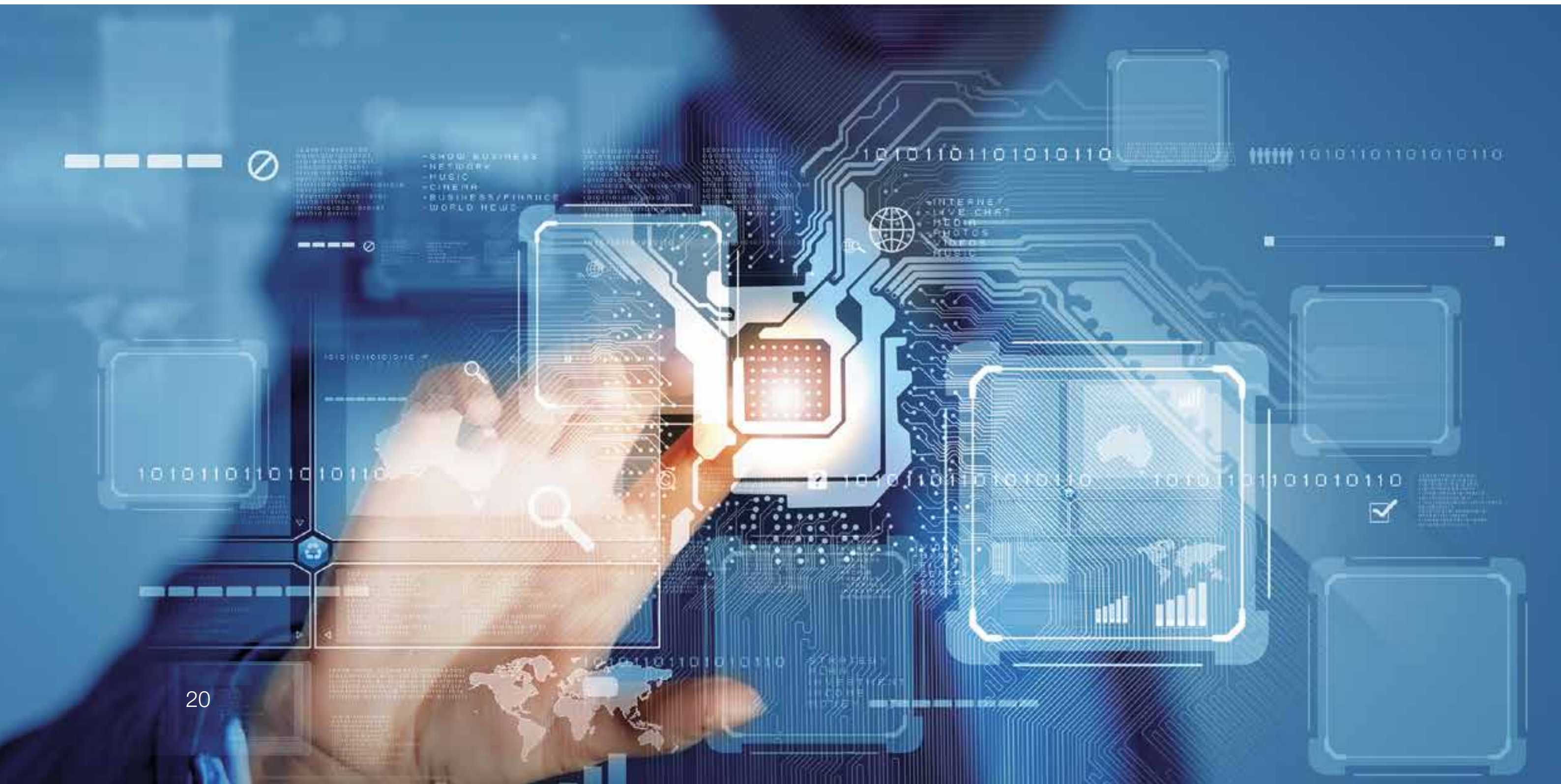


Table 1: Three Waves of Digital Automation
Adopted from Hawksworth et al. (2018)

Phase	Description	Tasks affected	Industries affected
Algorithm wave	Automation of simple computational tasks and analysis of structured data, affecting data-driven sectors (e.g., financial services).	Manually conducting mathematical calculations or using basic software packages and Internet searches. Despite increasingly sophisticated machine learning algorithms becoming available and commoditised, more fundamental computational job tasks will be most affected first.	Data-driven sectors (e.g., financial and insurance, information and communication and professional, scientific and technical services).
Augmentation wave	Dynamic interaction with technology for clerical support and decision making, including robotic tasks in semi-controlled environments (e.g., moving objects in warehouses).	Routine tasks that include the physical transfer of information (e.g., filling out forms and exchanging information). A decreased need for many programming languages is also likely, as repeatable programmable tasks are increasingly automated and machines themselves build and redesign learning algorithms.	Financial and insurance sectors, along with other sectors with a higher proportion of clerical support (e.g., public and administration, manufacturing and transport and storage).
Autonomy wave	Automation of physical labour and manual dexterity and of problem-solving in dynamic real-world situations that require responsive actions (e.g., transport and manufacturing).	AI and robotics will further automate routine tasks and tasks that involve physical labour or manual dexterity, including the simulation of adaptive behaviour by autonomous agents.	Construction, water, sewage and waste management and, with the advent of fully autonomous vehicles and robots, transportation and storage.

Source: Hawksworth et al. (2018)

The algorithm wave is the beginning stage of automation. It focuses on simple computational tasks and the analysis of structural data. Although the technological improvements represented by machine learning and big data are underway, the first wave of automation is largely limited to relatively simple computational jobs and tasks.

The second wave of automation is augmentation, by which routine and repetitive tasks, such as filling out forms and exchanging information, are automated. The development of robotics has allowed for the transformation of conventional machine capability and may supplement and augment the capacities of machines and computers.

The autonomy wave is the last stage, in which AI and robotics are further equipped with human-like (or often surpassing) cognitive and creative capacities. The cognitive power of AI will further advance and contribute to complex problem solving in dynamic real-world situations. Technological developments also allow machines to conduct adaptive tasks. Although it is not easy to predict the exact trajectory of digital automation in the future, it is fair to note that many developed countries have entered the second wave of automation and are advancing towards the third. However, many developing countries remain in the first wave or are making efforts to enter the second.

However, Hawksworth and Berriman's (2018) developmental predictive stage model is not the only one. Several stage or phase models of digital automation are being discussed and are under development in the field. Some are based on technological integration, such as islands and platforms, whereas others are based on the roles played by AI, such as assistant, advisor and actor roles. The available typologies are summarised in Table 2.

Table 2: Comparing the Developmental Stages of Digital Automation Collected and Compared by Jungwoo Lee

<table>
<tr><th>References</th><th colspan="12">Stages</th></tr>
<tr><td>(Davenport & Kirby, 2015)</td><td colspan="4">Dirty & dangerous automation</td><td colspan="4">Dull & automated automation</td><td colspan="4">Decision & intelligent automation</td></tr>
<tr><td>(Moore, 2015)</td><td colspan="6">Automation</td><td colspan="6">Digitalisation (work transformation)</td></tr>
<tr><td>(Kolbjørnsrud et al., 2016)</td><td colspan="4">Assistant</td><td colspan="4">Advisor</td><td colspan="4">Actor</td></tr>
<tr><td>(Eggers et al., 2017)</td><td colspan="3">Relieve</td><td colspan="3">Split up</td><td colspan="3">Replace</td><td colspan="3">Augment</td></tr>
<tr><td>(Brown et al., 2018)</td><td colspan="4">Assisted intelligence</td><td colspan="4">Augmented intelligence</td><td colspan="4">Autonomous intelligence</td></tr>
<tr><td>(Extreme Networks, 2018)</td><td colspan="6">Disconnected islands of automation</td><td colspan="6">Cross domain automation platform</td></tr>
<tr><td>(Genpact, 2018)</td><td colspan="6">Robotic process automation</td><td colspan="6">Intelligent automation</td></tr>
<tr><td>(Hawksworth et al., 2018)</td><td colspan="4">Algorithm wave</td><td colspan="4">Augmentation wave</td><td colspan="4">Autonomy wave</td></tr>
<tr><td>(IBM, 2018a)</td><td colspan="4">Basic process automation</td><td colspan="4">Advanced process automation</td><td colspan="4">Intelligent process automation</td></tr>
</table>

Although a variety of developmental AI models may predict the future trajectory of digital automation in terms of detail, they all share two critical characteristics. One is the 'intelligence level' that AI contributes in terms of technological development backed by the advance and integration of related technologies, such as sensors, big data and cloud. The other is the 'automation level' that may be achieved by implementing these artificial and machine intelligence capabilities in our jobs and tasks. These two characteristics are discussed in more detail in the following section.

Automation and Intelligence

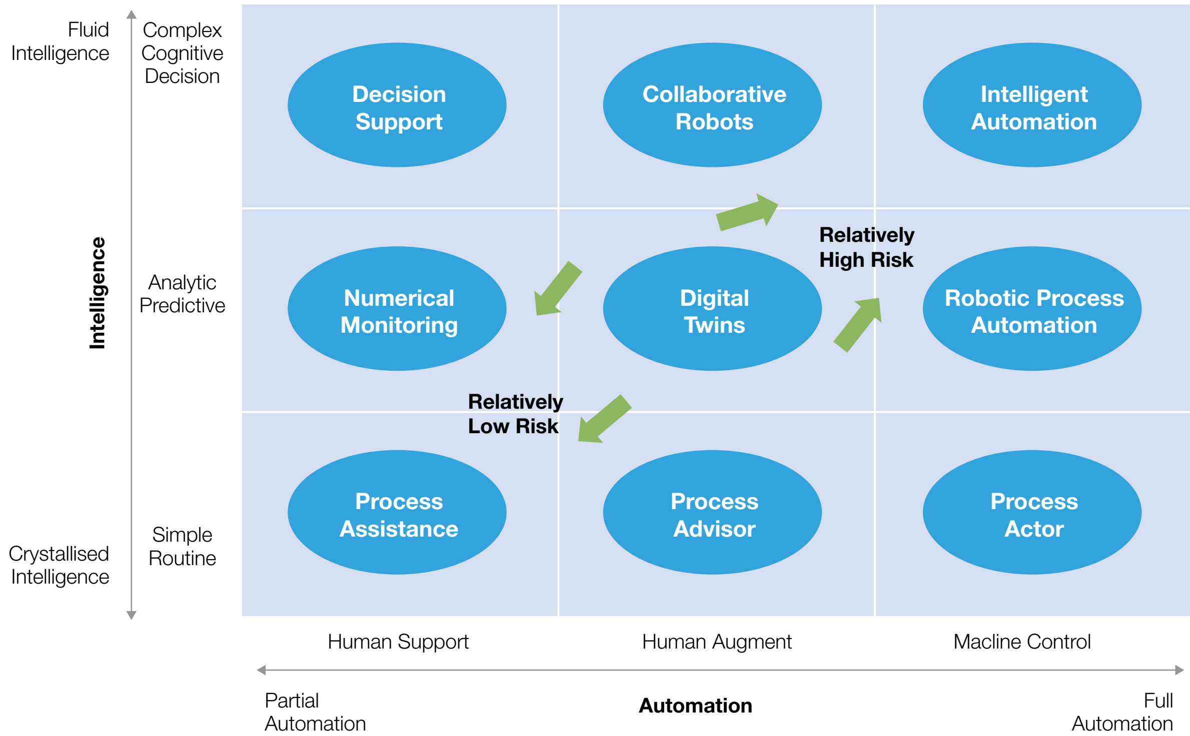
As pointed out earlier, two features seem to be prominent in defining this new concept of digital automation, compared to prior conceptualisations and applications of automation. One is the level of intelligence built into the machine. Using real-time big data analytics, machines may not only conduct simple and routine tasks, but also help and/or replace humans in complex and cognitive tasks. This was once considered beyond machines' capabilities. The other feature is the level of automation, including whether machines are supporting, augmenting or replacing humans in terms of tasks and processes, which may ultimately lead to fully machine-controlled situations. Using intelligence and automation as dimensions, a 3x3 matrix of AI typology is constructed as shown in Figure 2.

Intelligence level ranges from simple routine to complex cognitive in terms of how cognitively effortful the tasks are. Simple routine intelligence may be represented by crystallised intelligence, whereas fluid intelligence represents something that requires serious convergence of thinking in psychology (Cattell, 1963). This intelligence dimension may dictate the logics built in the machine and differentiate the different applications of digital automation.

Compared to the intelligence dimension, which defines the nature of tasks themselves, the automation dimension defines the scope of automation that may be determined by the designer – us humans. Digital technology can be used to support our decisions or, in extreme cases in which we can completely trust machine intelligence, the whole process can be automated without human intervention.

As the industry is now making a lot of effort to determine how to use AI in practice, consulting practices are developing different implementations of the general technology of AI. After collecting the terminologies that may emerge in the field right now, we place these implementable developments of AI in the 3x3 matrix below. AI technology has a bit more history than what we see right now – some implementations from decades ago. Each cell in this matrix is described very briefly in the following framing section.

Figure 2: Intelligence/Automation Matrix for Digital Automation Landscape Drawn by Jungwoo Lee



Framing Conceptualisations of Artificial Intelligence Technologies

The technological conceptions positioned in the nine cells of the above matrix are briefly explained and compared. It should be noted that some conceptualisations are decades old, as AI is not a new technology but has existed for decades. The conceptions are explained in sequence by the automation dimension subdivided by the intelligence levels in each dimension of automation.

Support

The automation dimension is scaled from AI support to the other extreme of machine control via AI without much human intervention. In this regard, support is the lowest level of automation. It refers to humans being supported by technologies. Depending on the level of intelligence embedded in the support of humans, three different types of support are conceptualised: process assistance, numerical monitoring and decision support.

- **Process Assistance (support for routine tasks)**
  Process assistance technology includes support for routine tasks that could be handled by humans. In some sense, old mechanisation based automation belongs to this category. Once a process is established in the real world without many exceptional conditions, the routine

tasks that humans conduct are then supported by computers. Paying bills after comparing the billing amount with the contract and shipping is an example. Without computerised processing, humans must compare the numbers and content of bills and contracts by hand and eye. However, once computerised, these operations can be easily handled by computers. Humans only need to inspect exceptional cases that computers may catch via comparison processes. In some sense, most business reengineering type technologies espoused in the 1990s belong to this category.

- **Numerical Monitoring (support for analytics and predictives)**
  The next level of intelligent support involves the basic level of analytics presented for human agents to make decisions. The purchase and sale of stocks via electronic devices with delicate analytics can be included in this category. Humans must set threshold conditions for the sale and purchase of stocks in computer algorithms. The system then presents the threshold conditions to humans for a final decision. Most processing plant operations also belong to this category of automation. When threshold values are met in processing chemicals, the system notifies human operators so that appropriate action can be taken.

  Compared to process assistance, the numerical monitoring category includes a bit more complicated, analytical and predictive formulae, which may be based on research. Whereas process assistance level technology involves the routinisation of day-to-day operations, numerical monitoring handles exceptional conditions that may require somewhat analytical capabilities.

- **Decision Support (support for complex and cognitive decisions)**
  Compared to numerical monitoring, which involves complex variable formulae, this decision support technology includes decisions based on a bit more longer-horizon information, such as strategic decisions. Decision support systems developed in the 1980s belong to this category, although the associated technologies were a bit less advanced.

  ‘Decision support’ may be a misnomer, as this terminology has been long used, especially in the information systems area, just because its concept appeals to the public, with its connotations about intelligent decision making via the help of technology (Sol, Cees, & de Vries Robbé, 2013). Decision support refers to technology that supports complex decision making, involving not only algorithmic processes, but also evaluative and heuristic processes. An example is a medical diagnosis system that facilitates doctors’ prognosis. As decision support systems have existed for a while, they have progressed with technological advancement. According to Sol (2013), decision support systems have migrated over the years. In the 1970s, they were described as computer-based systems for aiding decision making. In the 1980s, they were described as interactive computer-based systems that helped decision makers utilise databases and helped models solve ill-structured problems. Now, they are facing new challenges with the technological development of infrastructural technologies, such as the IoT and big data.

Augment

The next level of automation is referred to as the augmentation level in this framework. This level represents a higher automation level than simple support. Technology augments human actions and behaviour. It involves negotiation with human agents concerning the execution of decisions and tasks. Humans are augmented with, in addition to being supported by, intelligent technologies. Three types of intelligence augmentation are conceptualised here: process advisor, digital twins and collaborative robots.

- **Process Advisor (augment for routine tasks)**

  Process advisor technology is largely designed to augment process operators in terms of advising and helping. One example is a bit more advanced form of process assistance. For example, rather than providing simple comparison results of billing and paying information, a process advisor advises subsequent action items when discrepancy occurs, thus augmenting human operators' decision processes. The nuance of advising makes this level of automation different from simple assistance with processes involving a support function.

- **Digital Twins (augment for analytics)**

  Having numerical control of heavy machinery has a long history. The concept of digital control of heavy machinery is definitely not new. However, only thanks to cheaper IoT sensors and visualisation technologies, a replica of physical equipment can be visually constructed in a virtual or augmented reality – the digital twin. Gartner named this one of the top 10 new technologies in 2017. A digital twin is a virtual replica of physical equipment. Compared to its physical counterpart, the digital twin has historical and current data related to its operations, thus operators may monitor the workings, identify problems and take corrective actions in real time, while also examining the data collected from the physical counterpart in real time. Pairing the virtual and physical allows for the physical twin to be monitored, using real-time data from sensors, heading off problems even before they occur using preventive analytics and simulating changes in the virtual twin rather than in the real physical counterpart.

  Digital twin technology may be the ultimate and ideal form of digital automation, as it bridges physical equipment with the digital world. Sensors built into the physical device gather data in real time on the status and condition of physical components. These sensors provide the data to a cloud-based intelligence system that processes the sensor data along with other environmental condition changes and historical data. In this regard, the twin on the digital side is much smarter than its physical counterpart. Pairing this technology with visualisation capability would make life easier for workers who need to monitor and control equipment remotely.

- **Collaborative Robots (augment for complex and cognitive decisions)**
  In this augmenting arena, machines are not designed to make decisions on their own, especially in complex, cognitive and mission critical decisions. The critical difference between this level and full automation is the intentional use of intelligence technologies. A good running example of collaborative robots and further intelligent machine use is self-driving vehicles. The Society of Automotive Engineers defines six levels of driving automation (Society of Automotive Engineers, 2018):

  - Level 0: No automation
  - Level 1: Driver assistance (hands on)
  - Level 2: Partial automation (hands off)
  - Level 3: Conditional automation (eyes off)
  - Level 4: High automation (mind off)
  - Level 5: Full automation (steering wheel optional)

  For example, a Level 3 autonomous vehicle would belong to this collaborative robot category in which, by definition, machines augment human functions. However, Levels 4 and 5 would belong to the next intelligence automation level, such that machines make decisions independently. Due to technological uncertainty, automation would stop at the collaboration level and then proceed to the autonomous control of machines, eliminating any human participation.

Autonomous

The ultimate level of automation is referred to as autonomous machine control. This level represents the highest automation level among simple support and augmentation. On this level, technology makes decisions for humans. Negotiation processes with human agents are eliminated, although some post notice would be included in the technology. At this level, humans would find or create their own tasks aside from what they used to do. Three types of intelligence augmentation are conceptualised here: algorithmic process actor, robotic process automation (RPA) and intelligent automation.

- **Algorithmic Process Actor (autonomous for routine tasks)**
  This category is referred to as an actor, as this technology processes without human intervention in the case of routine processes. It is also algorithmic, as it may contain built-in routine processing algorithms. It is largely designed to replace process operators in terms of processing itself. Rather than advising or assisting, it processes autonomously. One example is the automated notification of discrepancy between billing and payment that may include explanatory notices to customers about why it is decided that way.

- **Robotic Process Automation (autonomous for involving analytics)**
  With the advent of digital automation in the age of AI, RPA has emerged as an important issue of choice for today's businesses. RPA does not refer to physical robots doing human tasks, but to software robots that help humans conduct the automated reengineering of business processes. One example is reconfiguring software, such as ERP, to suit changing business requirements. Research shows that RPA may operate as at least three full-time equivalent employees in switching processes quickly (Wilcocks & Lacity, 2015).

  Since the 1990s, when operation process reengineering was a basic application of IT, optimising business processes by eliminating unnecessary procedures and realigning remaining processes has been considered an important task of IT workers in organisations. Thus, many organisations have maintained teams for continuous process innovations, monitoring current processes along with environmental changes.

  In this regard, RPA is a recent development of process reengineering. It refers to the creation of software 'bots' that follow pre-set or learned processes and complete work that would otherwise require human intervention. RPA is expected to provide dramatic improvements in accuracy, reduce cycle time and increase productivity in transaction processes, relieving humans of the dull, repetitive tasks of monitoring and realigning.

  RPA may change the services delivery process from the customer perspective and for employees, substituting technology with people. It may also diminish labour demand. Furthermore, RPA may be used to solve the inevitable data growth that most organisations are experiencing in this age of big data. Big data analytics should be the basis for triggering specific RPAs.

- **Intelligent Automation (autonomous for complex and cognitive decision making)**
  This is the ultimate state of technology in which machines make complex decisions for humans without human intervention. A Level 5 full autonomous vehicle would belong to this category. In this state, machines replace humans in terms of decisions and actions, the consequences of which they may or may not notice.

  One cautionary note at this point is that this framing largely depends on our analyses of current technological development along with the conceptualisations found in industrial reports. Assumptions were made during the analysis phase and some may include conjectures and logical leaps. Also, as technological development is not only determined by technology per se, but also shaped by social construction, this framework may not be accurate in the future when technology is more advanced than it is now. However, we hope it at least provides a framework upon which to base further development efforts.

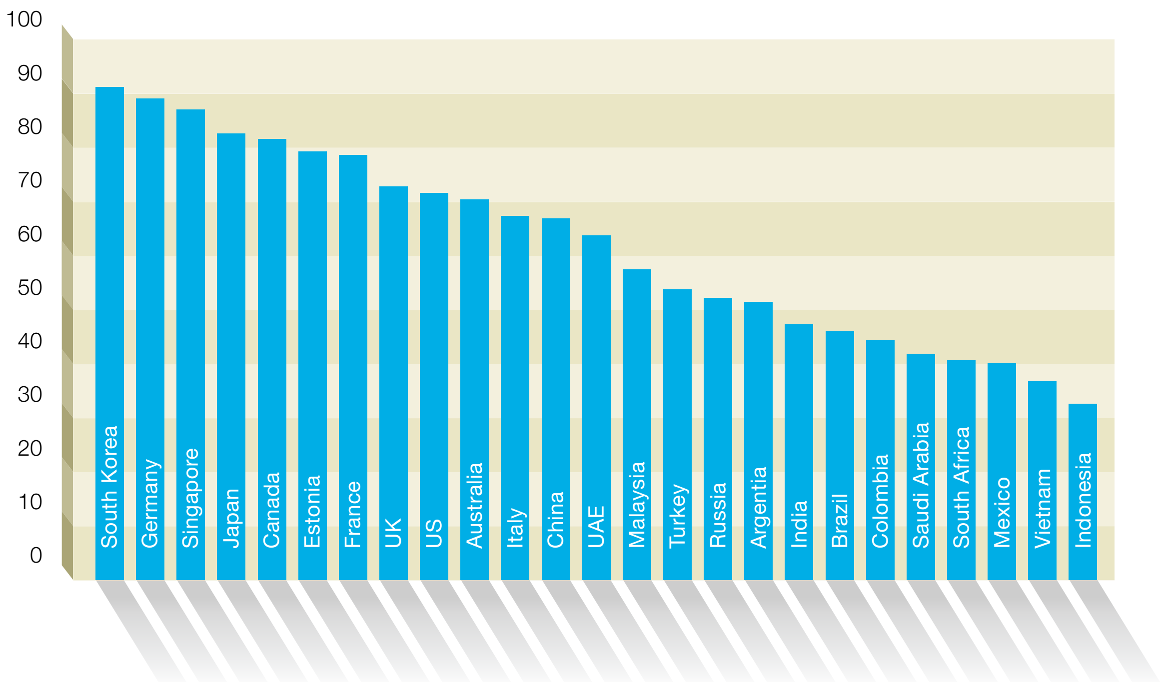
Automation Readiness Index Based Analyses of the Asia-Pacific Region

The Digital Revolution, also known as the Fourth Industrial Revolution, is expected to change all aspects of society, from industry to our daily lives. Core technologies, such as AI, robotics and the IoT, enhance the super-connectivity of people at any time and at any place (Schwab, 2016). AI extends this connectivity and increases its degree (Eggers, Schatsky, & Viechnicki, 2018). For example, government officials can use AI to identify the type of government communication that works best with various segments of people (Hawksworth & Berriman, 2018).

Automation Readiness Index

A recent report by The Economist's Intelligence Unit measured the Automation Readiness Index (ARI) for 25 selected countries (including all G20 countries and five additional countries representing different regions of the world) based on various technological and socio-economic indicators, such as innovation environment, education policies and labour market policies (Eggers, Rose, Mancher, Beyer, & White, 2018).

Figure 3: Automation Readiness Index



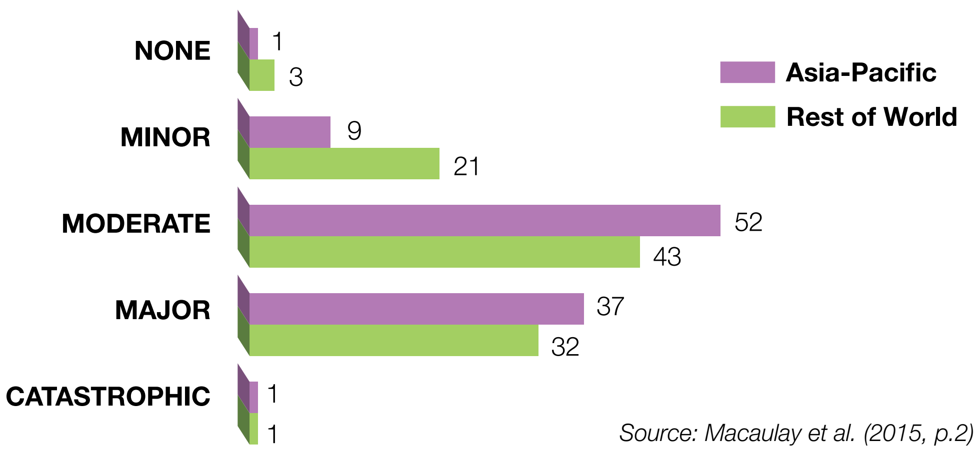
Source: Eggers, Rose et al. (2018)

Digital Automation in the Asia-Pacific Region

As Figure 3 indicates, high-income countries are better prepared for digital automation, although there is some variation among different countries depending on the extent to which governments make proactive efforts to prepare for automation. High-income Asia-Pacific countries appear to be more ready for the coming wave of automation than other regions among the G20 countries. For example, Korea (1), Singapore (3) and Japan (4) rank high in their ARI.[1] Of course, the figure also suggests a wide variation among Asia-Pacific countries. For instance, the ARI rankings of Vietnam and Indonesia are very low among the 25 selected countries. This suggests a wide disparity among Asia-Pacific countries in preparing for coming digital automation technologies, which may worsen the economic gap between them.

Recent studies suggest that the social impacts of digital automation technologies in the Asia-Pacific region are likely to be far greater than in other regions (Figure 4). According to a survey conducted by Macaulay et al. (2015), executives in the Asia-Pacific region expect digital disruption to be more serious there than in the rest of the world. For example, 90% of the survey participants believed that digital disruption affects their industries to a moderate or major degree compared to 79% of the respondents from the rest of the world. This suggests that the impact of digital automation may be much more extensive and stronger in the Asia-Pacific region than in other regions. Macaulay et al. (2016) also suggested that executives in the Asia-Pacific region believe that big data analytics (43%) and the IoT (43%) are the most significant and influential technologies among digital automation technologies, followed by cloud (37%), advanced robotics (26%), 3D visualisation (24%) and 3D printing (21%).

Figure 4: Perception of the Impact of Digital Disruption on Companies (% of Respondents)



Source: Macaulay et al. (2015, p.2)

[1] Different related indices are available. For example, according to the Artificial Intelligence Index developed by Pau et al. (2017) as part of an Asia Business Council report, China ranks in first place, followed by Singapore, India, Japan, Taiwan, Korea, Hong Kong and Indonesia. The Artificial Intelligence Index is based on the AI preparedness sub-index (start-up activity, AI funding, STEM human capital and AI publication) and the AI resilience sub-index (government AI policies and employment structure).

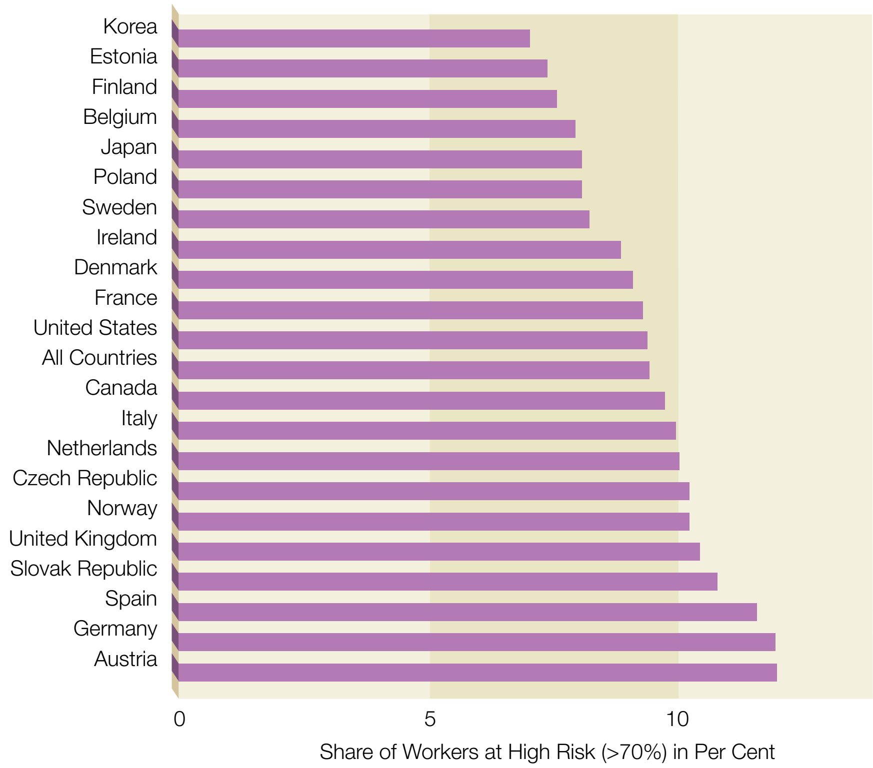
In summary, Asia-Pacific countries appear to be not only more interested in digital automation, but also more likely to expect to be influenced by it in the near future. Considering the continued advancement of digital technologies and their increasing impacts on various areas, it is important for Asia-Pacific countries to understand how digital automation affects various aspects, such as individual jobs, social structures and governments. The following section surveys how digital automation may transform human jobs, societies and governments.

Digital Automation, Jobs and Economy

As digital automation technologies advance rapidly, their social impacts are compelling and inevitable. However, despite the fast and continuous technological advancement of digital automation, there is no consensus regarding the extent to which these technologies specifically influence societies, particularly in socio-economic areas, such as employment, economic growth and social issues. Some tend to overestimate the impacts, whereas others tend to underestimate the speed, scope and impacts of such technologies. For example, there has been a long-standing debate about how computerisation and digital automation may affect various jobs in various fields. Frey and Osborne (2013) suggested that almost half (47%) of US jobs are at risk, with new technologies accelerating the replacement of these jobs. However, others have suggested that this prediction is unrealistic and somehow overestimated. Criticising the overestimation of the study, Arntz et al. (2016) asserted that the prediction by Frey and Osborne (2013) was overestimated, as it was calculated based on an occupation-based approach rather than a task-based approach and as it overemphasised the speed, feasibility and potential of new technologies, such as big data and AI.

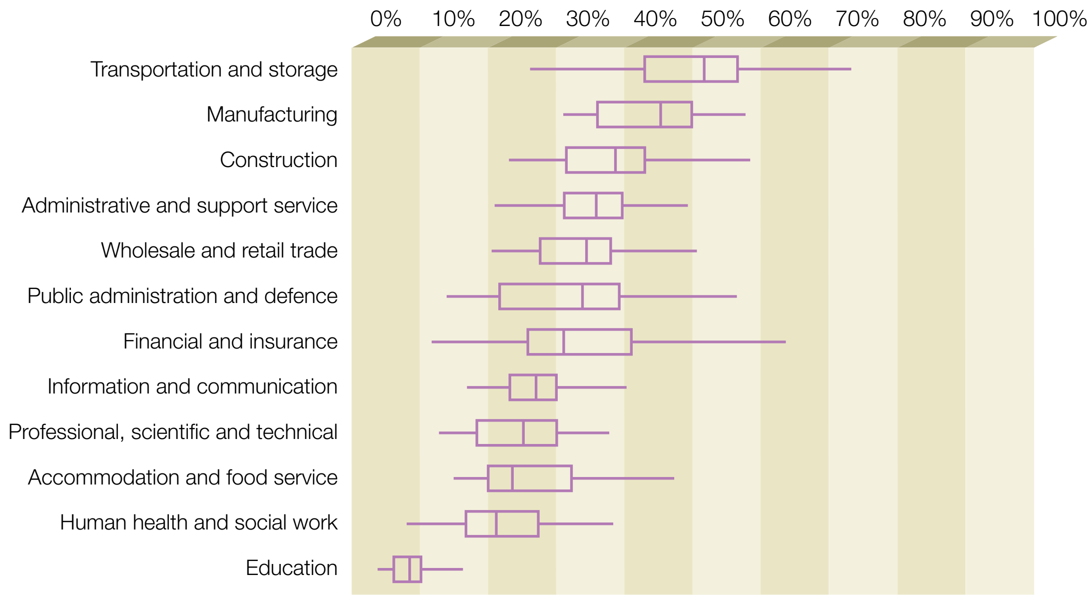
According to a report by Hawksworth and Berriman (2018), many countries are still in the algorithm wave (i.e., the beginning phase of automation) and although they may be moving towards the next two waves, automation is still confined to simple analytical tasks with well-structured data in areas such as finance, information and communication. It should also be noted that there are great variations in the speed of technological development and the degree of the social impacts of digital automation among countries that are very different in the distribution of tasks, occupations and industries.

Figure 5: Share of Workers with High Automatability and Share of Jobs by Industry



Source: Arntz et al. (2016, p.16)

Potential Jobs at High Risk of Automation



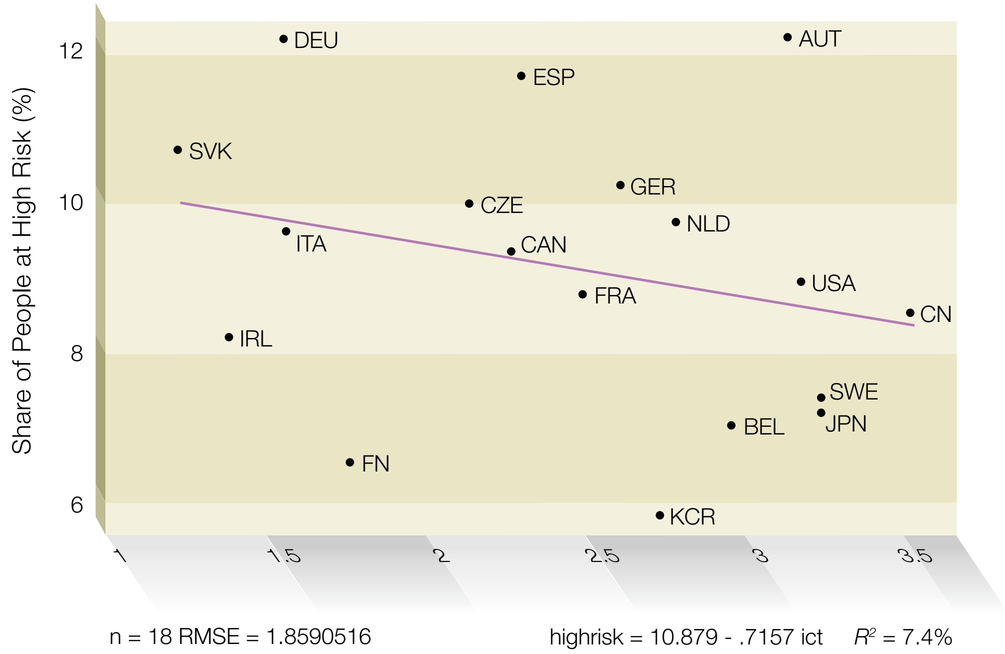
Source: Hawksworth and Berriman (2018, p.18)

Regarding the impact of digital automation on jobs, Arntz et al. (2016) took the task-based approach and used more extensive databases. Their findings suggest that overall 9% of jobs in OECD countries are at high risk (70% or greater) of digital automation. As shown in Figure 3, Austria and Germany have the highest share (approximately 12%) of workers who face a high risk of automation, whereas Korea has the lowest share (6%). Figure 5 also suggests that the risk varies across different industries. For example, approximately 50% of jobs are exposed to a high risk of automation in the manufacturing sector, where 31% and 20% of tasks are routine and manual, respectively. In contrast, only 8% of jobs are vulnerable to automation in the education sector, where manual tasks comprise only 10% of jobs. This indicates that task characteristics are the most significant factor in the variation of the shares of jobs at high risk (Hawksworth & Berriman, 2018).

Arntz et al. (2016) asserted that the proportions of workers facing high risk of automation in different countries are different due to variations in each nation's investment in ICT technology, education level and the share of communication tasks within jobs. As shown in Figure 6, countries that have already invested in ICT technology have lower shares of workers at risk compared to countries that have made low levels of ICT investment. This indicates that a high level of ICT capacity in a country somehow moderates the automation risk of jobs. Hawksworth and Berriman (2018) also found a negative relationship between the density of industrial robots and the share of jobs facing a high risk of automation. In addition, ICT is highly associated with global competitiveness, which implies a potentially strong association between digital automation and the global competitiveness of Asia-Pacific countries. Education also reduces automation risk. Arntz et al. (2016) discovered that education is the single most important factor moderating the risk of digital automation in employment, which suggests that jobs requiring a high level of education are still much safer than jobs requiring a low level of education.

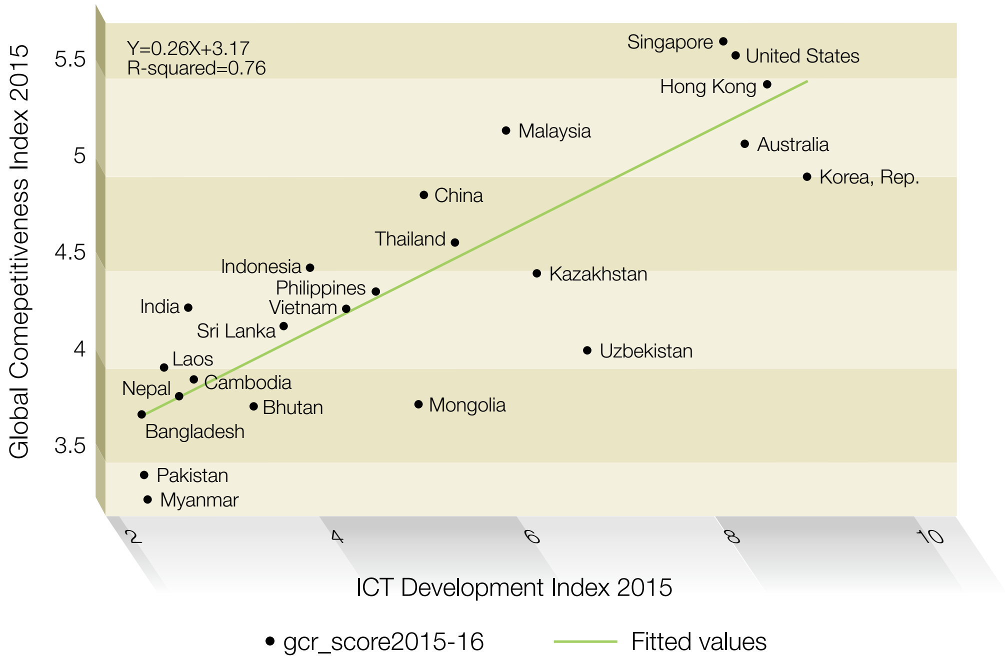
Figure 6: Impact of Information and Communication Technology Investment on the Automation Risk and Global Competitiveness of Asia-Pacific Countries

ICT Investments, Total, % of GDP (Latest Available Year)



Source: Arntz et al. (2016, pp. 1920)

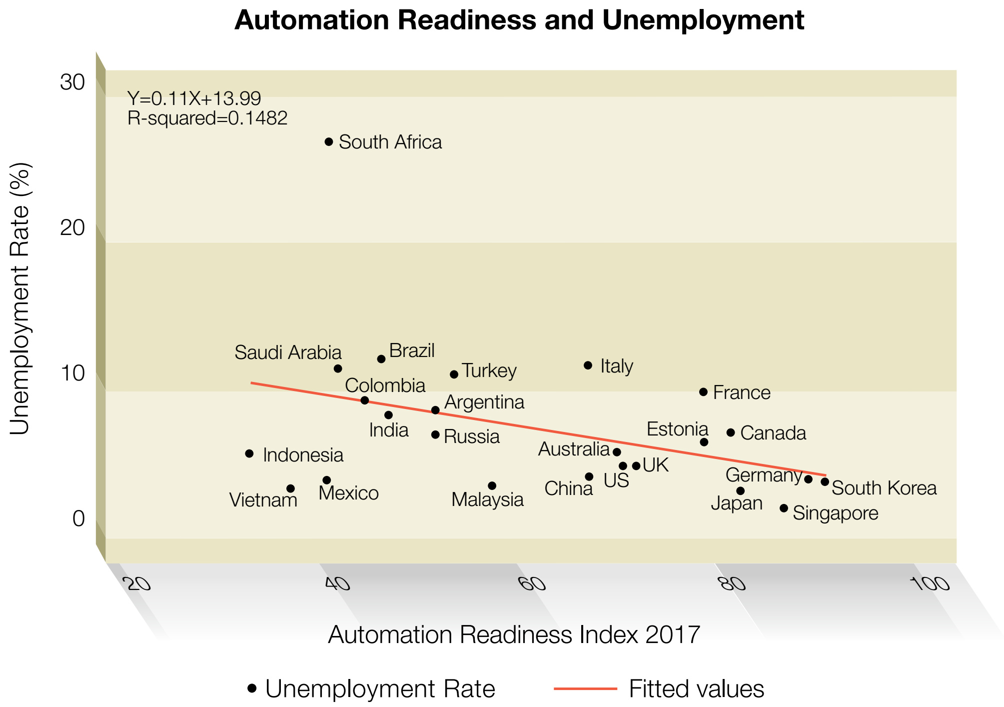
ICT Development and Global Comepetitiveness

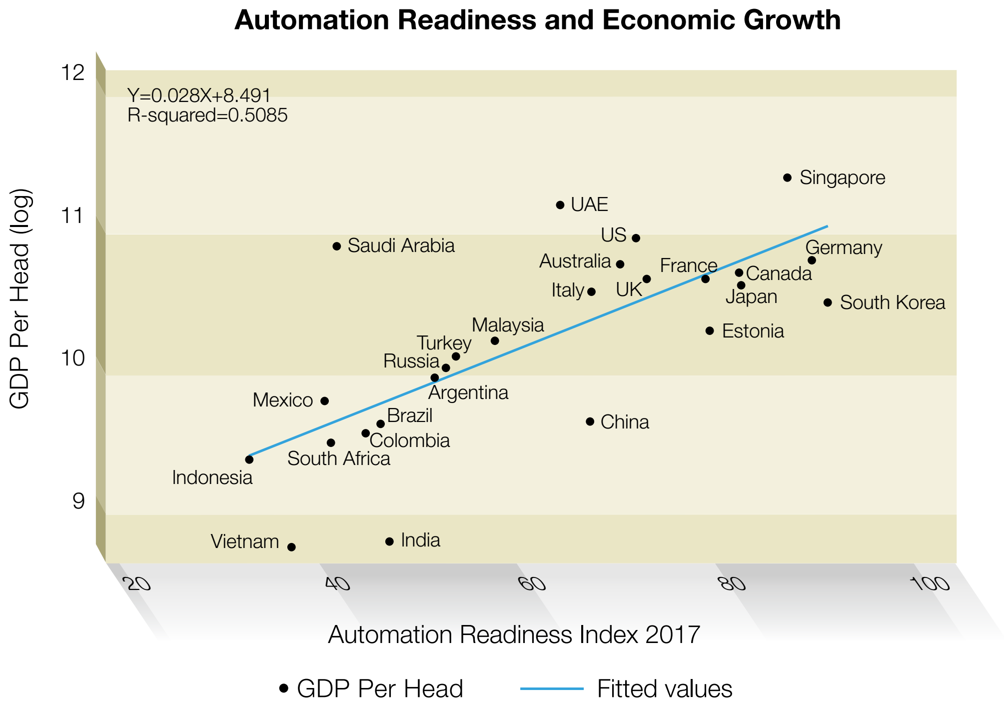


Source: Produced by Moon based on data from the ITU (2015) and WEF (2015)

How should we manage the risk of job automation? The findings of Arntz et al. (2016) and Hawksworth and Berriman (2018) imply that job automation may be moderated and reduced as we pay more attention to technological innovation and education by upgrading the nature of jobs with more sophisticated technologies and skills that are not easily replaceable. The ARI is calculated based on a number of indicators, such as government's R&D and innovativeness. Figure 7 shows how the level of ARI is associated with the unemployment rates and economic growth of selected countries. It suggests that ARI is negatively associated with unemployment and positively associated with economic growth. This means that a country that is better prepared for digital automation is likely to have a lower level of unemployment and a higher level of economic growth. Of course, the results should be carefully interpreted, as they do not necessarily confirm causal relationships regarding the effect of ARI on unemployment and economic growth. Despite the statistical limitation, the results imply that governments can overcome or at least moderate the negative impact of digital automation on employment and economic growth by allocating more resources and more proactive policy tools in the areas of R&D, education and innovation.

Figure 7: Digital Automation Readiness and Unemployment and Economic Growth





In summary, empirical analyses using the task-based approach show that the future of the workforce is not as pessimistic as Frey and Osborne (2013) suggested. What will be seen in the near future is not the demise of human labour, but the replacement of some tasks by digital automation. Workers will adjust their tasks and concentrate on productive activities as routine and administrative tasks are replaced. Arntz et al. (2016) predicted that people will still be important in more complex, creative and communicative tasks. For instance, the development of automated teller machines did not lead to the mass lay-off of all bank tellers. Instead of performing routine cash-handling tasks, they now focus on relational tasks, such as building rapport with customers and introducing them to additional bank services (Bessen, 2015).

Digital Automation and Social Transformation: Inequality and Quality of Life

Digital transformation fundamentally changes the way we live, work and communicate (Schwab, 2016). It brings both challenges and opportunities. Enhanced connectivity and intelligence allow people to make new products and services by accessing the digital world efficiently and affordably (Schwab, 2016). However, these technologies may produce greater inequality between those dependent on capital and those dependent on labour (Compaine, 2001; Schwab, 2016). In the following sections, we discuss the varying impacts of digital technology and automation on individuals' lives and societies both in the Asia-Pacific context and in general.

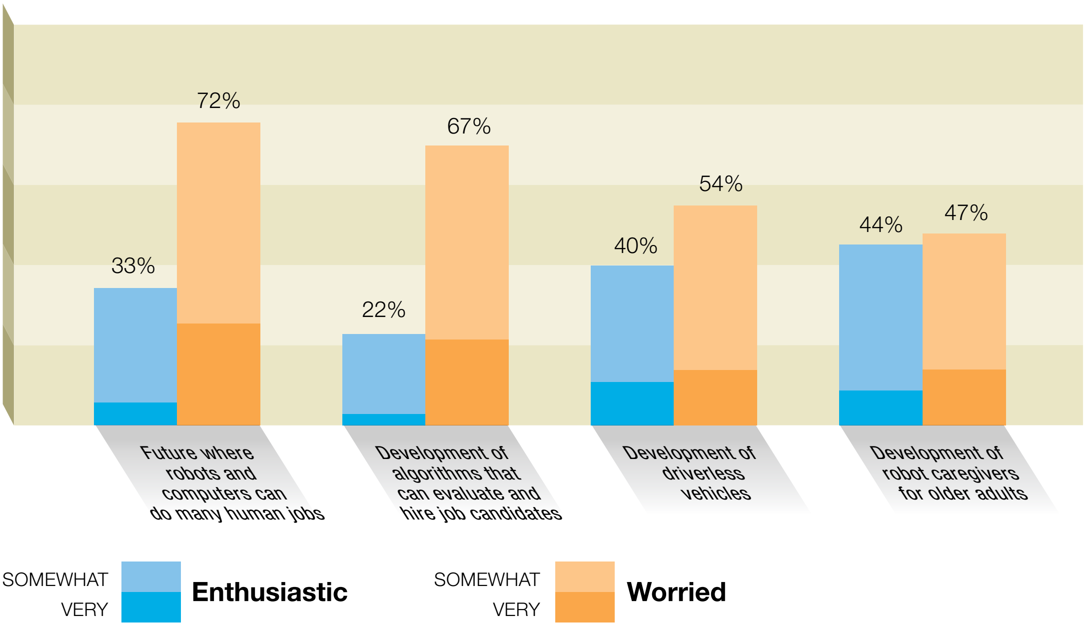
The impact of automation varies depending on the level of education and income (Arntz et al., 2016; Frey & Osborne, 2017; Hawksworth & Berriman, 2018). There is a stark difference in income between highly educated and less-educated groups. In particular, male workers with low levels of income and education are more likely to be exposed to the risk of a turbulent environment due to digital automation, as a majority of these individuals work in the manufacturing sector and are more exposed to high levels of automation than other sectors traditionally filled by low-skilled female workers, such as the service and education professions (Hawksworth & Berriman, 2018).

Solutions to moderate the negative impact of digital automation include enhancing the quality of worker-training programmes and improving income inequality (Arntz et al., 2016; Hawksworth & Berriman, 2018). The fear of digital automation is less likely to occur in societies where robust welfare systems are established, as labour unions and workers feel protected from the turbulent environment. For example, according to a report by the European Commission (2012), approximately 80% of people from Sweden, a strong welfare state, expressed optimistic views of new digital automation technologies, such as robots. However, Smith and Anderson (2017) found that more Americans express negative attitudes and concerns about the future of digital automation than those who are positive and enthusiastic about it (Figure 8). It seems that many people are still concerned about the negative impact of digital automation on economic inequality. Approximately 76% of Americans responded that digital automation might worsen economic inequality.

Figure 8. Views on the Future of Digital Automation

More worry than optimism about potential developments in automation

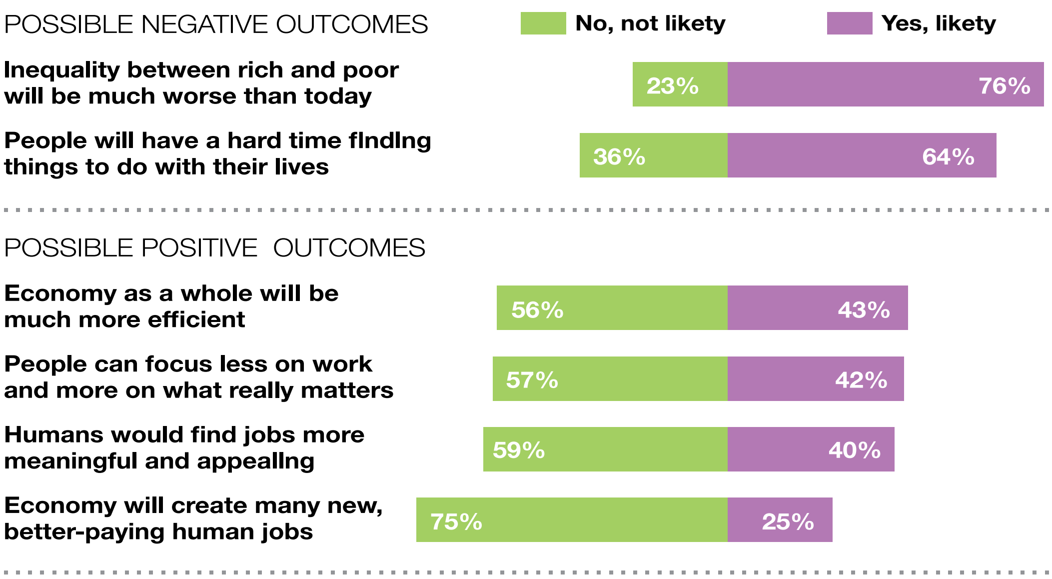
% of U.S.adults who say they are enthusiastic or worried about ...



Note: Respondents who did not give an answer are not shown.
Source: Survey conducted May 1-15. 2017.
“Automation in Everyday Life”
PEW RESEARCH CENTER

Public expects more negative than positive impacts from widespread automation of jobs

% of I.I.S. adults who say ___ is likely to result if robots and computers are able to perform many of the jobs currently done by humans

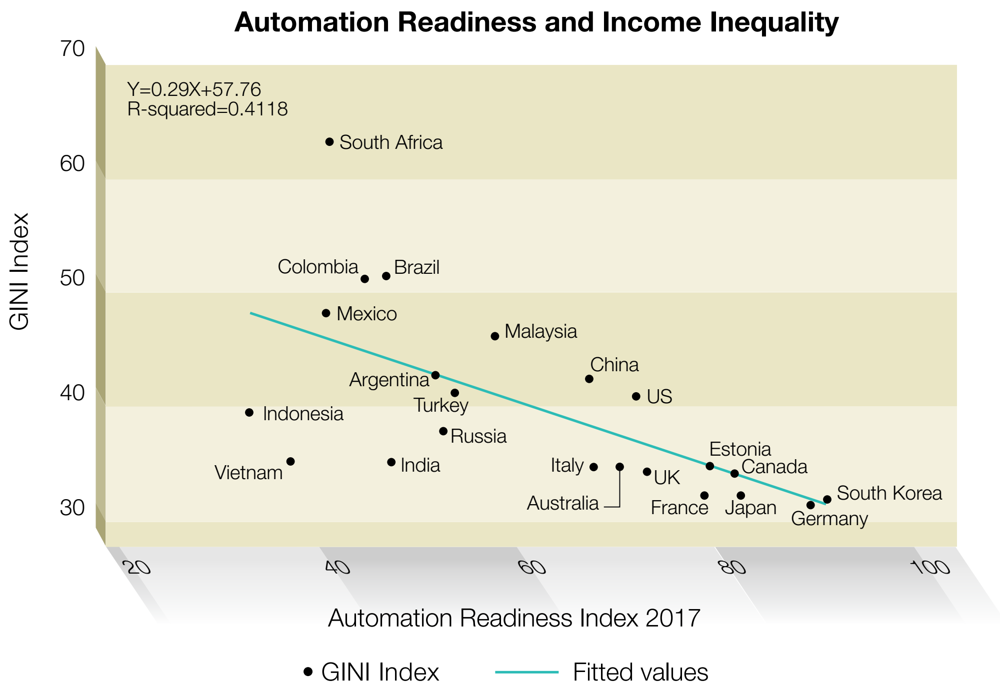


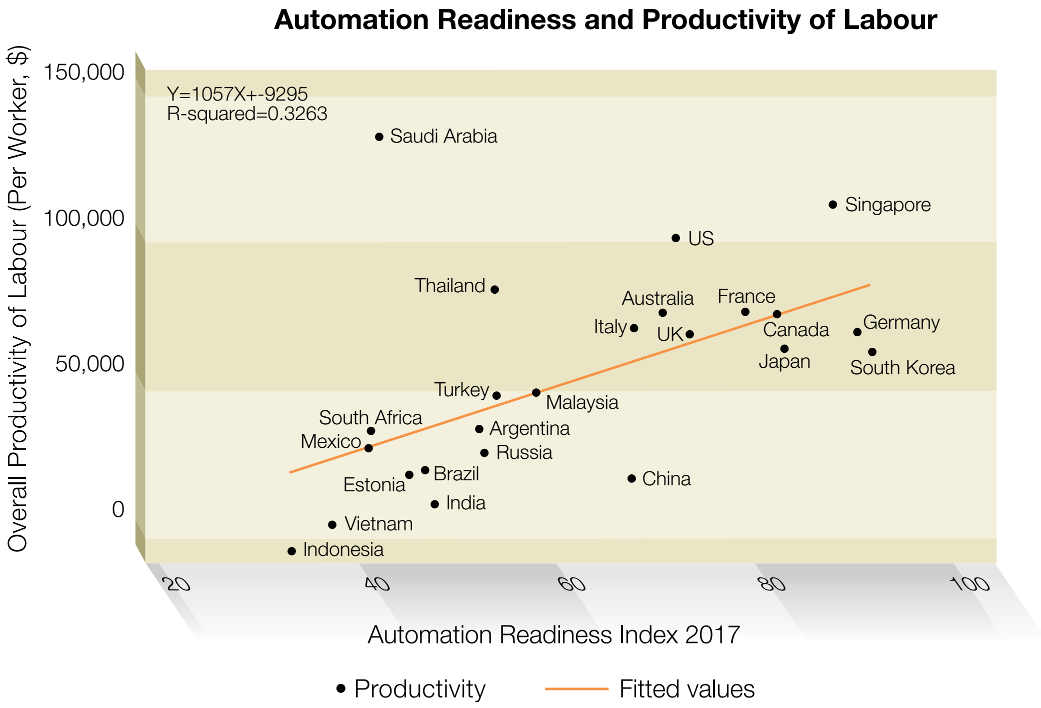
Note: Respondents who did not give an answer are not shown.
Source: Survey conducted May 1-15, 2017.
"Automation in Everyday Life.
PEW RESEARCH CENTER

Source: Smith and Anderson (2017)

Despite concerns about the potentially negative impacts of digital automation on economic inequality, countries that are better prepared for automation appear to more effectively cope with economic inequality. Figure 9 suggests a negative association between ARI score and Gini coefficient, indicating that those with a higher ARI level are likely to have a lower level of economic inequality. The figure also shows a positive association between automation readiness and productivity, which implies the possibility that digital automation helps enhance productivity level. As noted in the previous section, although binary relationships should be carefully interpreted, the results suggests that governments are encouraged to promote R&D, education and innovation functions for the improvement of income inequality and the advancement of labour productivity that are often suspected to be damaged by the influence of digital automation in a society.

Figure 9: Association of the Automation Readiness Index with Inequality and Productivity



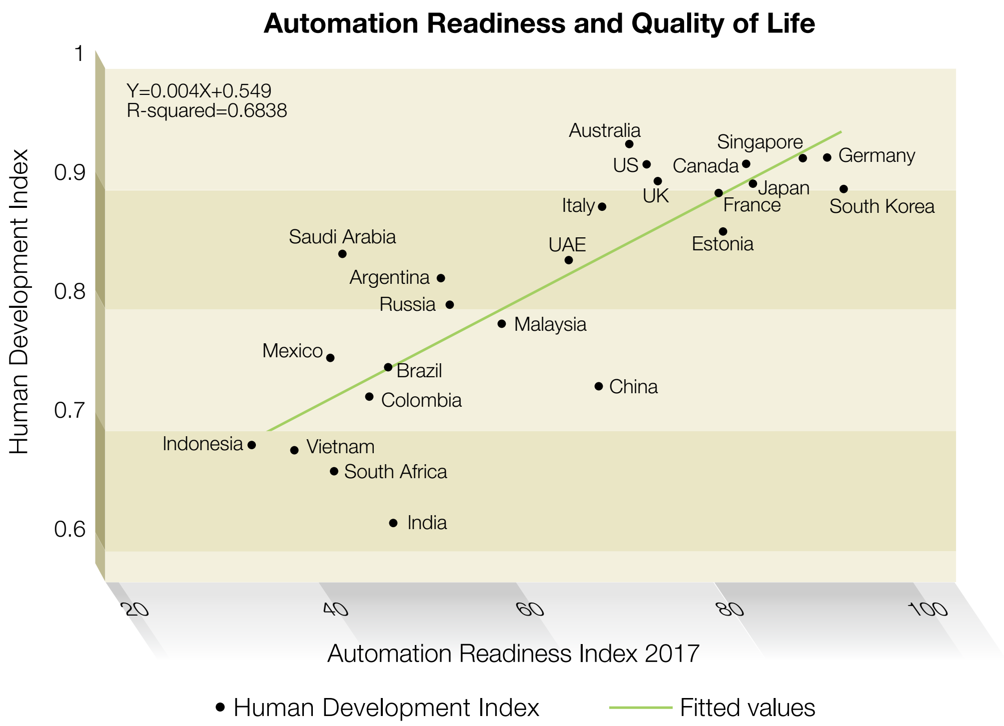


Source: Produced by Moon based on data from Eggers, Rose et al. (2018) and on GINI and productivity data from the World Bank, where productivity is measured by the overall productivity of labour (GDP at PPP per worker in USD)

How digital technologies have improved and how they will continue to improve human life and quality of life in developing and developed countries have been widely discussed. Similarly, automation technologies have already begun to change not only economic and industrial dynamics, but also quality of life and government operations. Quality of life can be measured in various ways. For the purpose of this paper, we use objective indicators, such as individuals' health, education and income status, which can be measured by the Human Development Index. According to the Global e-Sustainability Initiative's (2016) summary report, digital solutions provide individuals with better access to quality health services. For example, e-healthcare can benefit patients in developing countries by enabling them to consult with doctors through diagnostic video-conferencing and by reducing the cost of seeing doctors in person (GeSI, 2016). More advanced AI-based medical systems, such as Watson, have also been widely introduced. China recently reduced its number of lung disease patients substantially, despite a continued lack of medical doctors, with the help of an AI-based X-ray reading system developed by PereDoc, an AI start-up company (Sun, 2018). Sun (2018) reported that 131 Chinese companies are developing AI-based healthcare systems with great initiative taken by the Chinese government, expecting approximately USD930 million worth of the AI-health care system market in 2022.

Figure 10 indicates a positive association between ARI and quality of life, which suggests that a country that is better prepared for digital automation is likely to have a better quality of life. With growing digital automation in healthcare and other social services, quality of human life is likely to be substantially improved, thereby enabling individuals to spend much more time in non-economic and social activities in both physical and virtual communities. The results also suggest that a society may be able to better prepare to ease the potential negative effects but maximise the positive effects of digital automation on quality of life by introducing more proactive policies in R&D, education and innovation activities.

Figure 10. Digital Automation and Quality of Life



Source: Produced by Moon based on data from Eggers, Rose et al. (2018) and the Human Development Index (UNDP)

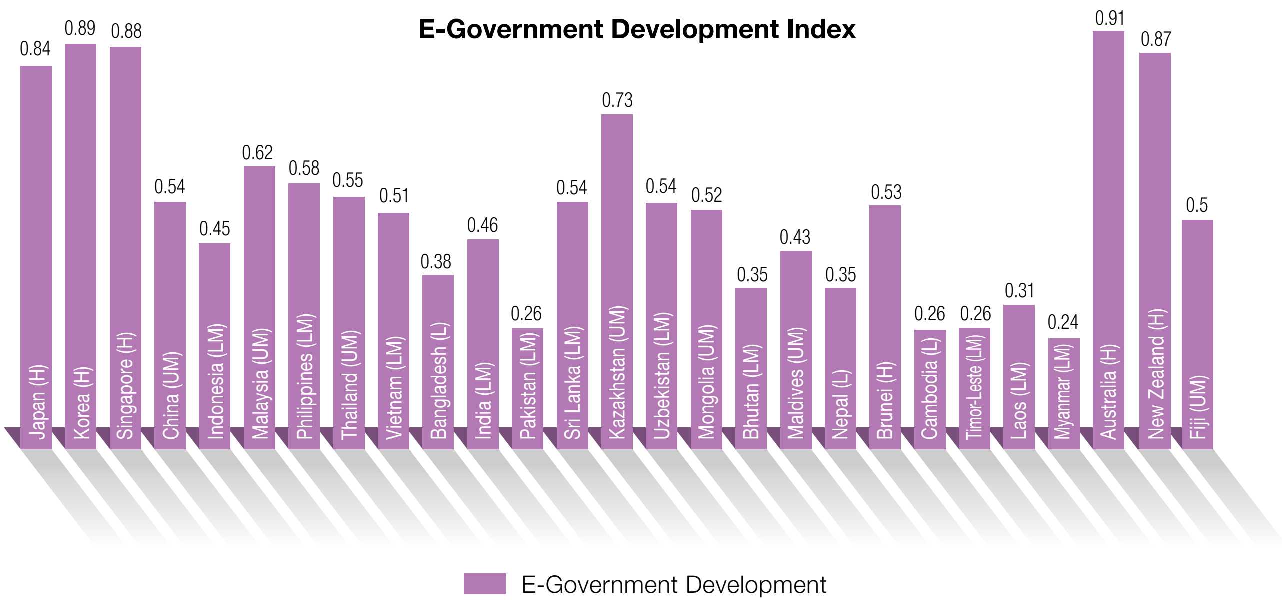
Digital Automation and Government Transformation: Digitalising Governments

In addition to contributing to quality of life, digital technologies are also recognised for being major external sources of enhanced government capacity (UNDESA, 2016). Digital technology and automation, in particular, have brought managerial and service innovations to the public sector. Dunleavy, Margetts, Bastow and Tinkler (2008) discussed how digital era governance is well managed (or mismanaged) by governments and insisted that governments must overcome the limitations of conventional government operations and public service delivery by taking advantage of ICTs as in e-administration (back-office applications), e-information, e-service (front-office applications) and e-participation.

Most governments take advantage of ICT for both front-office and back-office operations through digital government technologies. Although both developed and developing economies are interested in digital governance for the efficient operation of government and the effective delivery of public services, developing countries have been particularly interested in ICT-enabled administrative reform and public service delivery to improve the quality of government (QoG). According to the 2016 United Nations E-Government Survey, e-government has continued to advance in the Asia-Pacific region (Figure 9). Some Asian countries, such as Korea, Singapore and Japan, perform far better than other countries with similar income levels.

It should also be noted that there is a gap in e-government development among different sub-regions. The e-government development index for Kazakhstan is 0.72, whereas that for Malaysia, China and Thailand is 0.62, 0.60 and 0.55, respectively. Developing East Asian economies appear to perform far better than South Asian economies. The e-government development index for East Asian developing economies, such as Indonesia (0.45), the Philippines (0.58) and Vietnam (0.51), perform better than low-middle income economies in South Asia, such as India (0.46), Pakistan (0.25) and Sri Lanka (0.54). This suggests that developing East Asian countries take a more proactive approach than South Asian economies in taking advantage of ICT to improve the QoG, provide on-line public services and interact with citizens. Overall, the average e-government performance of Asian countries (0.51) is slightly above the world average (0.49), as indicated in Figure 11, which offers a comparison with the e-government performance of other regions.

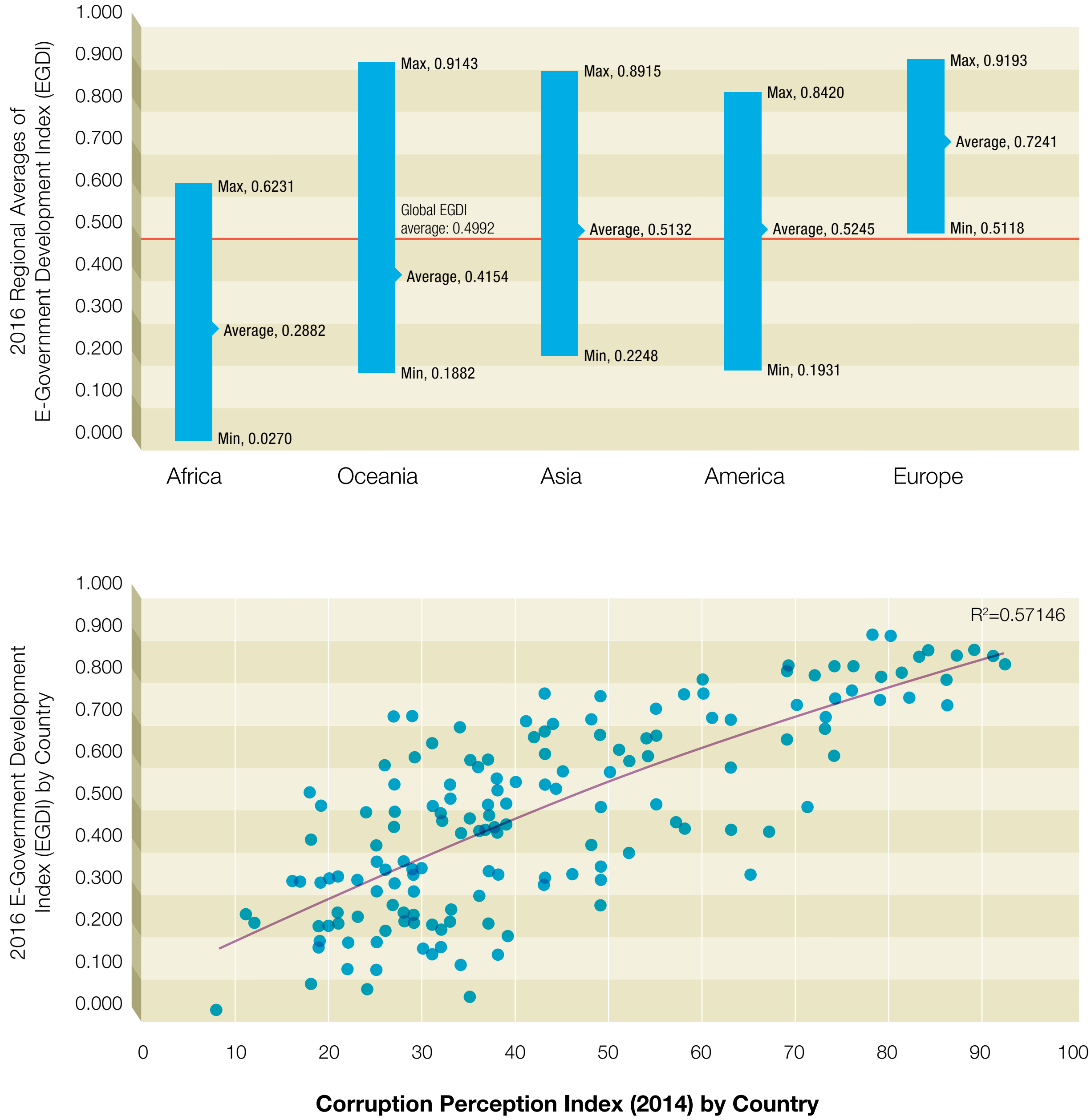
Figure 11: E-Government Performance of Asia-Pacific Countries



Source: Data obtained from UNDESA's (2016) E-Government Development Index 2016

Digital government is also a potential enabler in transforming the government sector by improving the QoG. In particular, there is a positive association between e-government development and reduced corruption. Furthermore, citizens' use of e-government helps restore and improve trust in government, as e-government services and the provision of information strengthen citizens' perceptions of the efficiency, transparency and effectiveness of government and enhance their sense of participation and empowerment (Welch, Hinnant, & Moon, 2005).

Figure 12: E-Government Performance by Region and Global Competitiveness



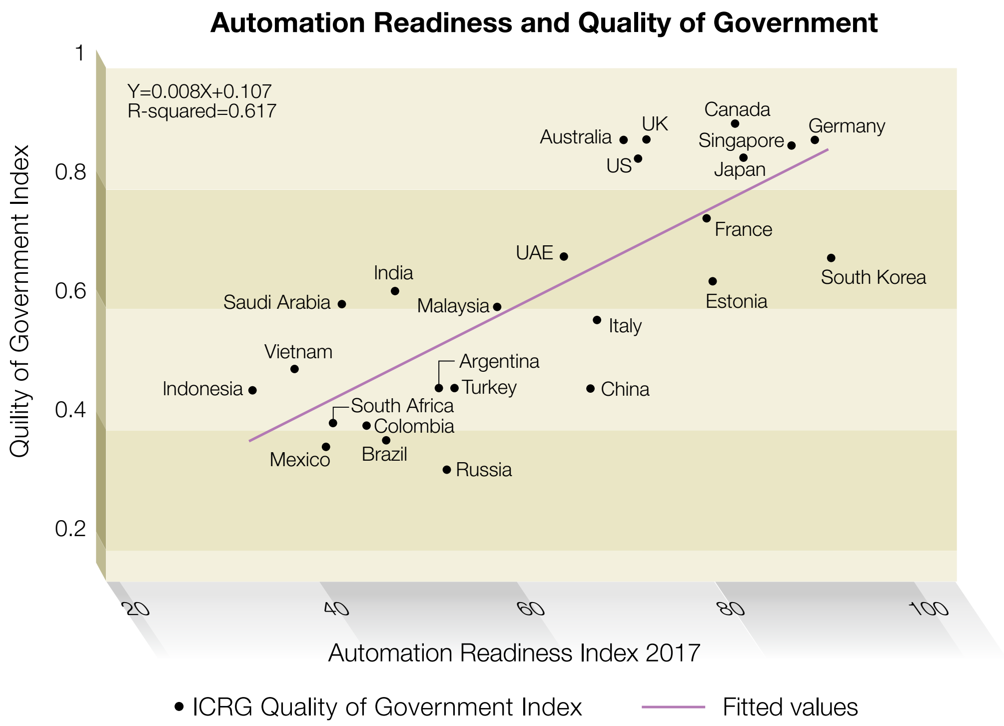
Source: UNDESA (2016)

Beyond the applications of ICT, digital automation technologies, such as AI, big data informatics and cloud computing, have been introduced to enhance the quality of government operations and public services. AI-based cognitive technology applications have been widely developed and used by government agencies to process large amounts of data, prevent fraudulent financial transactions and criminal activities and interact with citizens (Eggers, Schatsky, & Viechnicki, 2018). For example, using bots, RPA, can manage various tasks, such as handling citizen inquiries and requests, much faster and more accurately than manual work. Working with Microsoft, the Singaporean government developed a chatbot-based system through which it provides selected public services (Mehr, 2017). In 2017, the Daegu metropolitan government of South Korea developed Du-bot, a chatbot-based system for handling citizen inquiries about various public services, such as passports, taxes, parking services and civil reports. The Du-bot system has been made available on mobile so that citizens can access it easily.

Machine learning and big data analytics have been widely applied, especially in policy areas where policy-related big data, such as crime, pollution, transportation and public health information, are available. For example, in the area of crime prevention, governments have already used so-called PredPol (predictive policing) systems by applying automated algorithms to identify crime hotspots based on crime-related big data and then take action to prevent crimes. These systems have had positive results in places such as Los Angeles, New York (Domain Awareness System), Seattle and Kent (Bell, 2018; Robinson & Bogen, 2017).

Digital automation has been widely applied in various policy areas. This trend will continue and will eventually help improve the QoG. Figure 13 suggests that automation readiness is positively associated with QoG. This implies that digital automation is expected to improve the quality of public services in various policy areas by allowing governments to take more proactive and preventive actions than before, while also enhancing the efficiency, effectiveness and transparency of governments as a result of augmented capacities by various AI-based systems.

Figure 13: Association of the Automation Readiness Index with Quality of Government



Source: Produced by Moon based on data from Eggers, Rose et al. (2018)

With continued advances in ICT and automation technologies, the public sector will gradually transform into an AI-augmented government (Eggers, Schatsky et al., 2018). As Eggers, Schatsky et al. (2018) claimed, government capacities will be augmented as governments apply digital automation technologies for internal administrative operations and external public service delivery and citizen engagement. Moreover, digital technology, in particular AI, will become increasingly important for policy makers at different stages of the policy-making process (Tito, 2017). For example, in the agenda-setting stage, governments will be able to analyse the information obtained from social media platforms and understand public opinion regarding specific policy issues. They will also take proactive and preventive actions using preventive analytics, such as in the case of PredPol in the Los Angeles Police Department (Robinson & Bogen, 2017). Increased information and analytical capacity will further allow public managers to develop customised policies for specific policy target groups in the decision-making process (Dunleavy et al., 2008; Tito, 2017).

Although digital automation offers great prospects for government operations and public services, it should also be noted that governments must pay attention to potential challenges in the public sector. As in the private sector, digital automation will affect public services and employment in the public sector. Despite the prospect of replacing citizen consultation and administrative routines by algorithm and AI-based automation, such as chatbots, street-level bureaucrats who often engage in face-to-face interactions with citizens will not be completely replaceable. Although highly politically sensitive policymaking tasks may be conducted with the assistance of digital automation, such as big data analytics, digital automation will only have a supplementary role in the policy process and public service delivery, as public officers' face-to-face interactions with citizens will continue to be important for citizens' trust in government (Kettl, 2015).

It should also be noted that machine learning tends to be based on the trends and patterns of historical data. Potential biases against less privileged groups, such as women and minority ethnic groups, may continue in automated decisions primarily due to past data-dependent patterns (Robinson & Bogen, 2017; Tito, 2017).

Lastly, there is also a potential risk of government over-surveillance and ignorance of due process in pre-emptive and preventive enforcement as governments introduce more administrative and policy actions through digital automation. This risk should always be checked by not only internal systems, but also external formal institutions and informal watch groups.

Discussions and Policy Implications for the Asia-Pacific Region

Digital automation is becoming more prevalent in our daily lives, as robots, AI and informatics are more widely applied in various social areas. It is not an optional matter but a constant variable in any country, as it has already begun to influence (and will further influence) business and industrial structures, jobs, social dynamics and governments. In general, digital automation is expected to bring both benefits and challenges. Although digital automation will offer new positive opportunities in the long run, thanks to its reduced costs and enhanced capacities as experienced in past industrial revolutions, it will also lead to compelling challenges and risks by disrupting existing economic, social and public systems. The magnitude of the negative and positive impacts of digital automation will be largely determined by the extent to which a country can and is willing to take advantage of the beneficial aspects of digital automation and minimise the potential negative impacts. Industrial and technological structure, innovative and entrepreneurial environment, education and ICT infrastructure are important factors for coping with the prospects and challenges of digital automation.

Asia-Pacific countries particularly need to pay attention to the prospects and challenges of digital automation simply because they are more likely to be influenced by digital automation than other regions considering the sheer volume of economies, industrial structures and social characteristics and the automation readiness of these countries. In particular, developed Asia-Pacific economies, such as those of Japan, Korea, Singapore and Taiwan-China, demonstrate that ICT and digital automation are becoming an increasingly indispensable element of economic, social and governmental development. It is also true that there are wide gaps between Asia-Pacific countries in terms of their industries' automation preparation and their governments' policy packages to promote the positive impacts and reduce the negative impacts of digital automation.

Several developing Asian countries are trying to transform their resource-based economies to knowledge-based economies. For example, mainland China has taken an aggressive approach to digital automation by both industries and governments in the belief that digital automation technologies will pave the way for it to become a world superpower. Other developing countries, such as Malaysia and India, also appear to be paying increasing attention to the potential benefits of digital automation and to value its critical role in transforming and upgrading industry, society and government. Of course, many developing Asia-Pacific countries are not yet fully prepared to incorporate digital automation technologies into their own economic, social and governmental functions.

There is no one-size-fits-all policy, but we suggest three main areas where swift and immediate action should be taken to ensure a greater positive impact of digital automation for economic, social and public sector development. To maximise the potential utility of fast-changing digital automation technologies, Asia-Pacific countries must make tough but significant policy choices in consideration of various factors, such as government capacity, stage of development and digital automation readiness. Our three primary policy recommendations include 1) promoting digital automation technologies to enhance productivity and social well-being; 2) reducing the potential negative impacts of digital automation by proactively moderating the risks involved in job replacement, social inequality and the abuse of big data held by governments; and 3) promoting digital automation application services for government operations and public services.

Harness Digital Automation Technologies to Enhance Productivity and Social Well-being

Taking advantage of the opportunities of digital automation technologies, Asia-Pacific countries must incorporate the potential of digital automation into their economic and social development plans. This starts with comprehensive assessments of the global and regional competitiveness of their industries and the quality of their labour, innovation and education systems. This also requires proactive government actions to promote R&D in related technologies and improve regulatory frameworks to accelerate the introduction of digital automation in not only the private but also the social and public sectors. The introduction of digital automation will enhance productivity and economic competitiveness with more competitive and value-added jobs and will improve citizens' quality of life.

Just as the Industrial Revolution started in Europe and the US overwhelmed Asia, digital automation may prevail in the future as the predominant technological paradigm, priming industries and governments with a strong advantage over countries that do not adopt such technologies. This would be critical for new job creation and for baseline productivity gain in current industries. Plans must be made to develop and adopt digital automation technologies in the private and public arenas.

Reduce the Potential Negative Impacts of Digital Automation

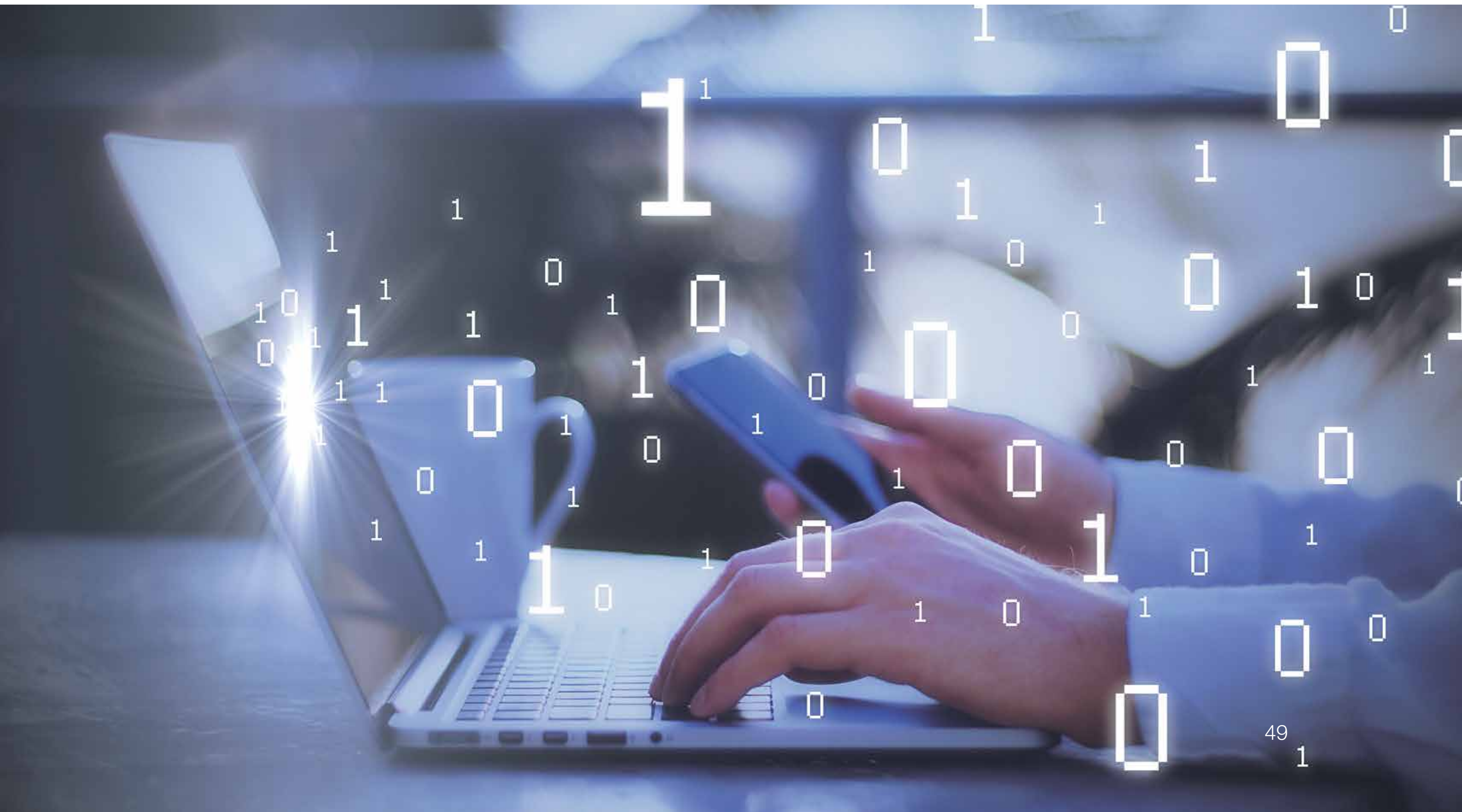
Despite the positive contributions of digital automation, it inevitably puts many jobs and social systems at high risk in the course of replacing traditional jobs, distributing productivity gains among various groups and providing public data informatics-assisted public services. Asia-Pacific countries must identify the complexity of each risk and resolve it through appropriate policy packages. For example, policymakers should combine labour, education, tax and social welfare policies to moderate the risks of job replacement and social inequality arising from digital automation. Governments should also have comprehensive policies and technical solutions to prevent the potential abuse of public information and protect privacy when private information is processed and used by digital automation systems.

Promote Digital Automation Application Services for Government Operations and Public Services

Digital automation offers great potential to improve administrative efficiency and the quality of public services. As many Asia-Pacific countries have taken active initiatives for e-government performance through both the back-office and front-office applications of ICTs, they must incorporate digital automation in the development of future AI-augmented and networked governments. This requires governments to prepare a comprehensive roadmap for developing digital automation-embedded government platforms and to train bureaucrats to be more technologically savvy.

Devise National Policies to Help the Workforce Transition into the Digital Automation Era and Prepare Younger Generations

Some jobs may disappear and new jobs may emerge much faster than we anticipated with this digital automation. As our data show, education and training may mitigate the serious impact of digital automation. Workforce transition requires extensive retraining as digital automation infiltrates our businesses and societies. New expertise is needed in the automated environment and workers must be trained for this new era. Specifically, they need to obtain knowledge about newly converged processes. Furthermore, new generations must be prepared differently, meaning that the educational system needs to be revised accordingly. A crystallised intelligence focused education system using 18th century pedagogical means may already be obsolete.



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CHAPTER 2

Technological Change and its Consequences: A Brief History for the Future

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Technological Change and its Consequences: A Brief History for the Future

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Abstract

This chapter provides an overview of perspectives and analyses of technological change up to the present day. Our intention is to understand the development of disruptive technologies and their consequences, mainly for employment and work. We seek to identify key consequences of technological change as these issues are likely to provide pointers for the consequences of emerging technologies. Taking a long view, we find that occupations and industries have grown and contracted over time. The third industrial revolution has encouraged the rapid expansion of more complex jobs for which there is demand for higher education skills, but many routine jobs remain. Routine jobs attract less earnings over time, so that pay inequality has become a feature of contemporary economies. The growth of high-skilled, non-routine jobs plateaued in the fourth industrial revolution leading to anxiety about the future. Much future-oriented analysis is based on the experience of Western countries although variations in these countries tend to be downplayed.

In turning to the Asia-Pacific countries, we see considerable diversity in the timing of industrialisation and the adoption of new technology. Nevertheless, technological change has been the handmaiden of economic development. Occupational and industrial change has unfolded in a similar way to the major Western countries, however, the employment effects have been more benign: lower levels of unemployment and rising wages. Acknowledging variation in government policies, we interrogate national differences in approaches to technological change. We show that some governments (e.g. Singapore and China) strongly promote new technology, while others (e.g. Australia) emphasize corporate facilitation by maintaining a conducive environment and providing relevant information. Overall however, all governments endorse the notion that new technology has the potential to bring more good than harm. In order to highlight these different approaches more clearly we provide four vignettes of technological change at the firm and industry levels. The paper outlines several key policy implications of our analysis and concludes with seven suggestions for further research.

Acknowledgements: Thanks to Maria George for excellent research assistance.

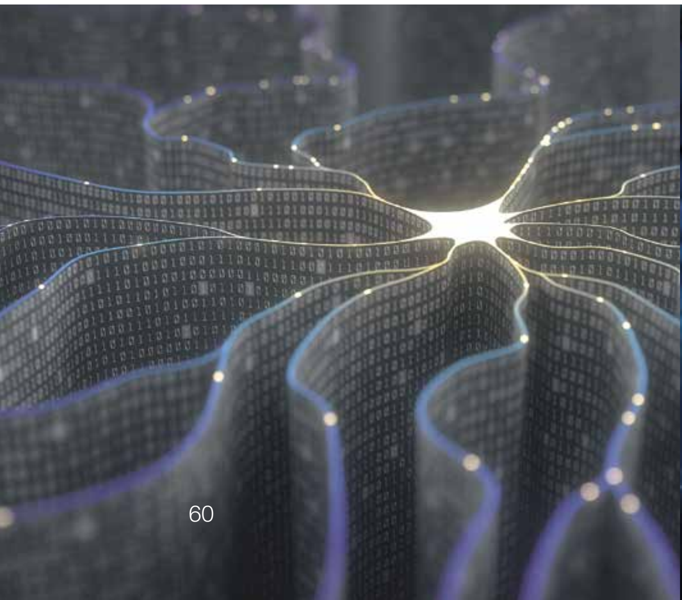
Introduction

This chapter provides an overview of research findings concerning the impact of technological change on employment and selected aspects of work. This theme strikes a chord today as there is much discussion in the media about technological change destroying jobs and the rise of artificial intelligence that might disempower and even control skilled workers. Anxiety about job displacement is not new but it is more likely in times of economic stagnation (Mokyr, Vickers & Ziebarth, 2015). Thus, Keynes, writing in 1930, warned that "The increase of technical efficiency has been taking place faster than we can deal with the problem of labour absorption; the improvement in the standard of life has been a little too quick" (Keynes, 2016, p.321). While it is not possible to predict the future, it is useful to learn from history, so we take a long view, beginning with the first industrial revolution and investigating the implications of technological change for employment and work. We pay particular attention to the period since the 1970s – the beginning of the third industrial revolution (Schwab, 2016; Gordon, 2012) -- as this provides a window that is relatively close to our future, indicating the probable continuation of some trends and suggesting important lines for future enquiry.

Being dependent on previous research, our review necessarily reflects a similar bias towards developed Western nations, but where possible we have sought data and analysis from the Asia-Pacific region. This is important because some trends are not universal and depend significantly on national characteristics, including history and natural endowments. A second caveat is that while our selectivity regarding the consequences of technological change also reflects the availability of studies and ultimately relevant data, we do highlight gaps which investigations of future technology should consider based on the proposition that these anticipated consequences are too important to neglect from both research and policy points of view.

We restrict our definition of technological change to the adoption of new conceptual and material techniques by economic organisations (Schumpeter, 1942). This refers to innovation and diffusion rather than the act of invention. Our focus is on the past, that is, on change that has occurred and which research can, in principle, identify consequences. We are not concerned with current changes whose consequences can only be guessed at or estimated with limited precision. We seek to identify change which is break-through and disruptive rather than incremental, while acknowledging that incremental change may in time prove to have disruptive consequences. Our review is mainly concerned with the following consequences: the extent of job creation and destruction; the broad sectors and occupations that are most affected; and changes in the distribution of skills, pay and job quality. We propose that particular technologies – electricity and digitalization, for example – represent major breaks with the past that have been adopted universally, albeit at different rates of diffusion. These technological changes warrant special attention. However, countries also differ in the adoption of specific new technologies which reflect their particular resource endowments, level of development, and political economic characteristics. Referring to specific Asia-Pacific countries, we discuss these differences and illustrate how new technology is being adopted by countries in the Asia-Pacific region.

The rest of the chapter is structured as follows. We adopt the view of leading scholars in outlining four stages of industrial revolution and their employment consequences based on disruptive technologies. In the second section we provide a detailed examination of several key consequences: the changing distribution of different types of jobs and employment and job quality since 1970 based largely on the experience of Western countries, particularly the US. In the third section we consider technological change and its consequences in the Asia-Pacific region. Acknowledging country differences, we briefly analyse several national public policies regarding technological change. This is followed in the fourth section by four vignettes of technological change in different Asia-Pacific countries at the industry and firm levels. The fifth section provides several discussion points and conclusions regarding implications for understanding future technological change and its effects.



Technological change: the long view

Western experience of technological change has been divided into several stages. According to Brynjolfsson and McAfee (2014), the First machine age comprises the period 1750-1970s and the Second machine age begins in the late 1960s and stretches into the future. The first stage is based on mechanical machines which replaced manual labour while the second stage is based on digital technology which replaces cognitive labour. Gordon (2012) has a similar periodisation, except he divides the first machine age into two stages, the first, approximately 1750 to 1890, being the initial industrial revolution based on the steam engine while the period thereafter until the 1960s is the second revolution based on the internal combustion engine and electricity. The third industrial revolution begins in the late 1960s based on the computer and the emergence of the internet. As shown in Table 1, this categorization is extended to include a fourth industrial revolution based on mobile internet technology and artificial intelligence (AI).

Table 1: Stages, technology bases and employment consequences of technological change

Industrial revolution	Major technologies	Impact on employment and work
1st (late 18th C)	Steam engine	Decline of agricultural jobs. The emergence of skilled manual jobs.
2nd (20th C – 1960s)	Electricity, internal combustion engine	Growth of manufacturing jobs. Emergence of technical and managerial jobs.
3rd (1970s – 2000s)	Computer/internet – digital technology	Substantial decline in routine jobs. Emergence of knowledge workers.
4th (2000s – present)	Mobile internet. Artificial Intelligence	Emergence of digital working class; routine cognitive work is replaced by machines; increased rewards for social skills

Source: Schwab (2016).

The first industrial revolution began in England and later spread to Europe and the US. It was dominated by the steam engine but included many other inventions whose application significantly increased productivity in agriculture and in the cotton and steel industries. Overpopulation and technological change resulted in rural unemployment. However, manufacturing industry grew rapidly, gradually absorbing the unemployed. The early 19th century witnessed a growth in skilled machine-related work which replaced handicrafts and semi-skilled, routine jobs whose pay and conditions gave rise to the notion of the 'sweatshop.' Inferior pay and conditions were addressed later through factory legislation and the growth of trade unions.

The second industrial revolution included the expansion of large industrial enterprises based on mass production. Semi-skilled labour became widespread as did clerical and service work. This was a period of proletarianization although skilled workers remained relatively well paid. In the US, trade unions were strongly contested by employers, however in other Western countries, unions negotiated acceptable pay and conditions for their members, except in the Great Depression (1929-39) when the world economy contracted.

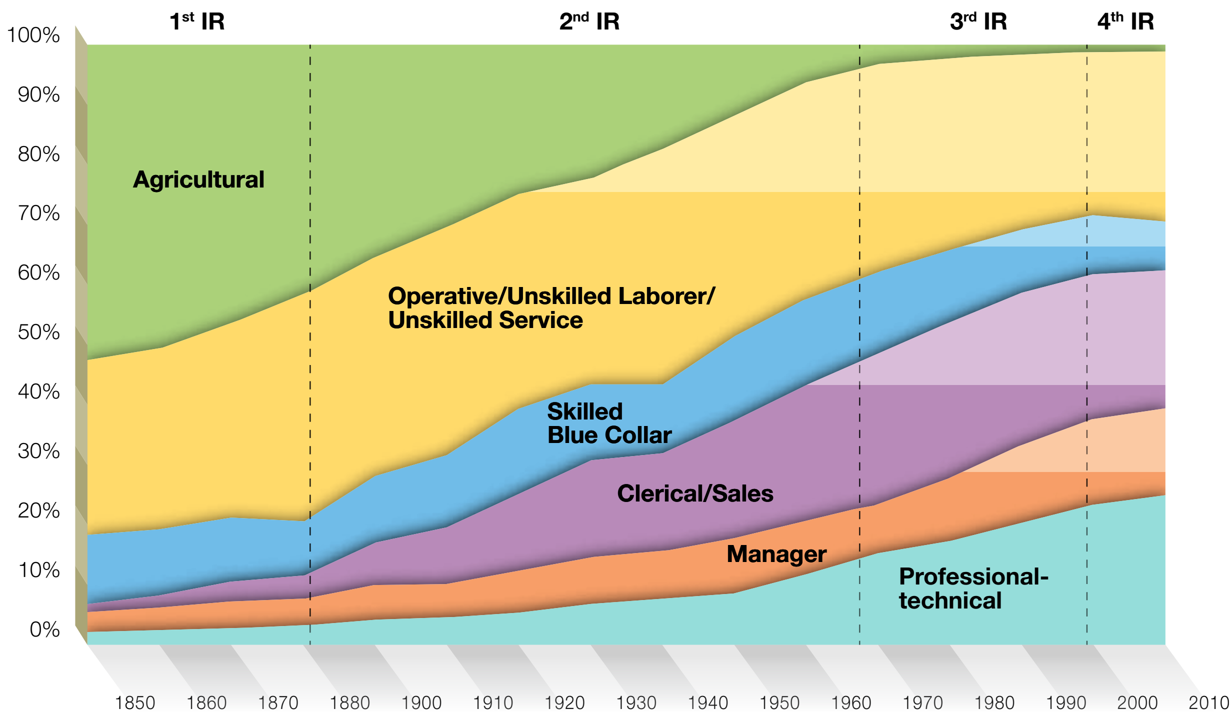
The third industrial revolution was based on digitalization, manifested in the diffusion of the personal computer and the beginning of internet usage. Many new kinds of IT-based occupations emerged or expanded, including software designer, desktop publisher, and computer games developer. Indeed, technical work grew rapidly as computers were widely introduced and began to increase in power as microchips became faster and smaller. Computer applications increased productivity, particularly in the office, enabling connectivity so that persons and firms working in different locations and time zones could collaborate more easily. The reduction in costs associated with the internet and mobile phones resulted in an explosion in horizontal communications: individuals could more easily create social movements and influence politics (Castells, 2007). Increased business to business connectivity encouraged the growth of international supply chains that have come to dominate international production and trade (ILO, 2016). Nevertheless, the economic benefits of digitization have been controversial. Thus, Gordon (2012) draws on empirical evidence to argue that the digital revolution did not promote faster economic growth in the US. On the contrary, except for the period 1996-2004, contemporary growth has been slow suggesting that digital technology has not had the major impact that many commentators have imagined.

This brings us to the 4th Industrial Revolution (4th IR), a period coined by Klaus Schwab, the founder and chairman of the World Economic Forum and widely cited in public discourse and government policy documents. It proposes that we are currently experiencing disruptive change manifested in various new technologies such as autonomous vehicles, 3D printing, advanced robotics, and nanomaterials. The 4th IR builds on the information and digitalization technologies of the 3rd revolution but is distinguished by its faster speed, wider scope, and stronger change intensity. However, some observers (Garbee, 2016) are sceptical about the distinctiveness of the 4th IR, arguing that it is not uncommon for public intellectuals to claim a ‘new age’ when in fact this does not materialize. In the next section, we review existing evidence pointing to significant changes in employment levels and work characteristics, including pay and working conditions.

The impact of technological changes on employment structures and pay in Western countries

Technological change has shaped the distribution of employment in various occupations and industries over time. Pay levels have reflected the changes in demand and supply of various types of work (see below). Figure 1 shows changes in the occupational distribution of US civilian employment since the mid-19th century.

Figure 1: Occupational distribution of civilian employment, US, 1850-2010

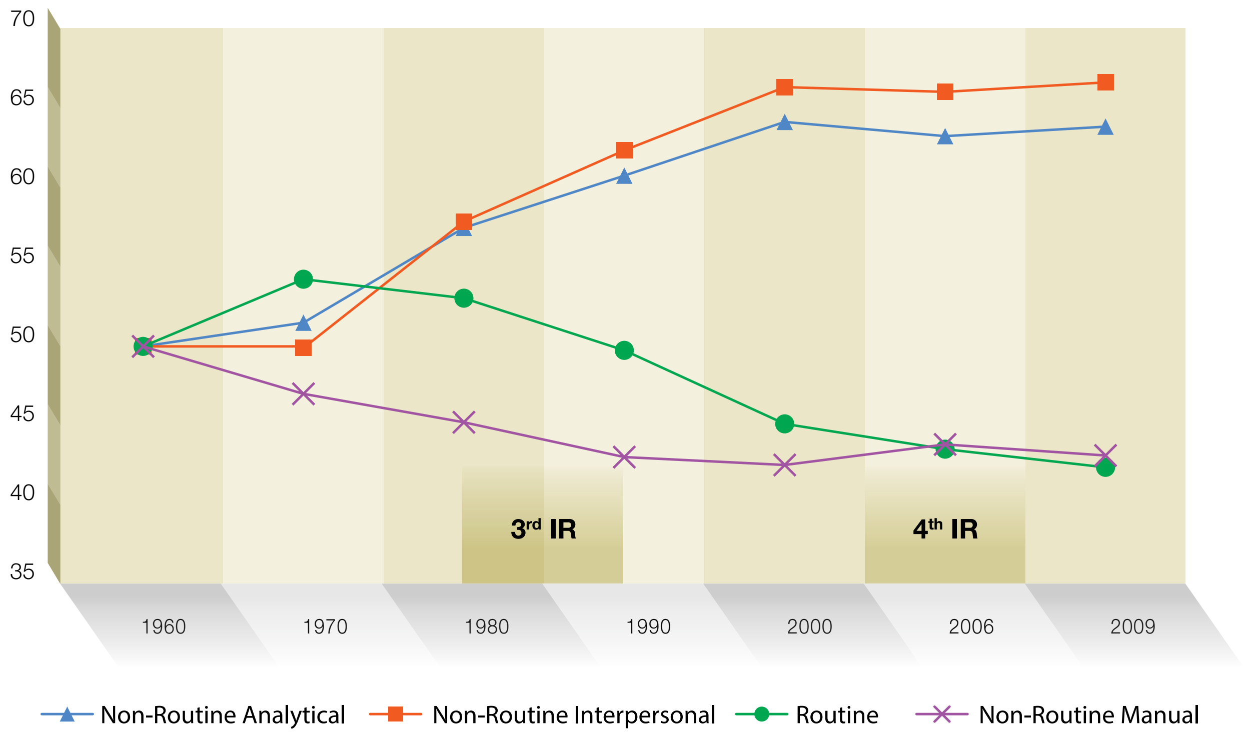


Source: Data from Katz and Margo (2014).

Figure 1 shows that agricultural employment declined substantially during the first and second industrial revolution after having occupied centre stage prior to 1850. At the start of the 3rd IR, agricultural employment contributed less than 5 percent of US employment. Semi-skilled operatives and unskilled labourers had been declining since the onset of the third industrial revolution. This trend seems to have been reversed during the 4th IR. Skilled blue-collar employment has been largely steady throughout the entire period although it began to decline in the 4th IR. Clerical and sales have been stable and service occupations have increased, particularly since the 2nd IR. More complex, cognitive jobs are included under the titles of managers and professional-technical. These jobs have been increasing in relative terms, particularly the latter, which are sometimes referred to as 'knowledge work' (Frenkel et al., 1999) and comprise the backbone of both the third and fourth industrial revolutions.

A more nuanced approach to the changing nature of work is to view jobs as bundles of tasks along two dimensions: complexity i.e. routine vs non-routine; and key skill usage i.e. cognitive vs interpersonal. Figure 2 shows the varying demand for US jobs classified into four types during the third and fourth industrial revolutions.

Figure 2: Changes in Occupational Task Intensity in the US, 1960-2009



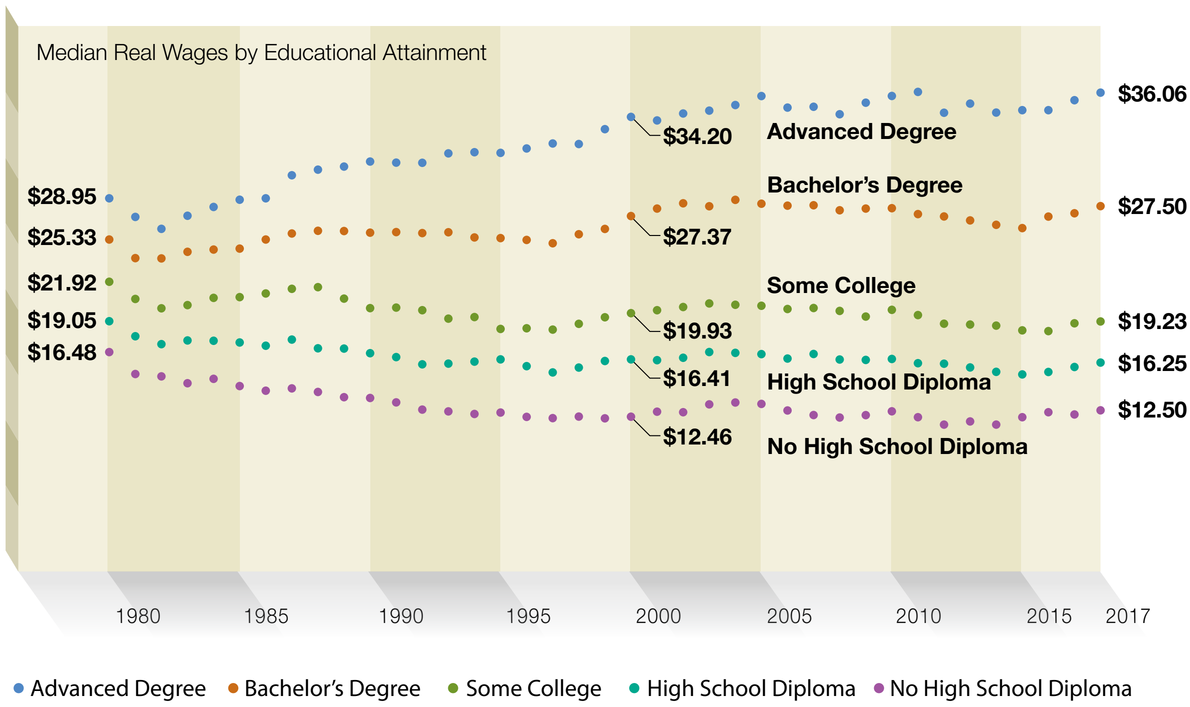
Source: Data from Autor and Price, 2013. Variables are set to 50 centiles in 1980.

Figure 2 shows the pattern of changes in the demand of non-routine interpersonal, analytical and manual jobs compared to routine jobs in the US. Before the coming of the 3rd IR, routine jobs were apparently in higher demand than non-routine jobs. This trend was reversed in the 1980s by the growth of non-routine analytical and interpersonal jobs. During the 3rd IR, the gap between the demand for routine jobs and the demand for non-routine cognitive jobs (analytical and interpersonal) grew substantially. The broader gap between routine jobs and non-routine cognitive jobs has been maintained in the 4th IR. Particularly noteworthy in the 4th IR is the higher demand of interpersonal non-routine jobs compared with analytical non-routine jobs. Deming (2017) suggests that the US labour market increasingly rewards employees' social skills because computers are currently a poor substitute for human interaction.

This demand disparity in jobs is reflected in the returns to education. Prior to the consolidation of the digital economy in the 1980s, college degrees did not yield significantly greater returns compared to high school degrees. In other words, the pay of high school graduates was not much different to that of university degree holders. However, as shown in Figure 3, the pay gap thereafter increased substantially. This growing educational wage gap reflects technological changes from the 1970s to the mid-1990s (Card & DiNardo, 2002).

Figure 3: Education pay gap in the US, 1979-2017

Wages in 2017 dollars



Source: Figure from Donovan and Bradley, 2018.

Figure 3 shows that the real wage of employees with qualifications above a Bachelor's degree has the highest growth rate and level of pay. This is also the case for employees with Bachelors' degrees, although the upward trend is less visible. In contrast, high school graduates' real weekly earnings have been declining slightly since the onset of the 3rd IR indicating that relative to demand, the supply of mainly routine work is fairly plentiful. These data suggest the skill shortages for more complex jobs increased during the period of the 3rd IR. This is in line with the UK CES (2013) report which suggests that 43 percent of job vacancies in the fields of science, technology, engineering and mathematics, were difficult to fill owing to skill shortages (Balliester & Elsheikhi, 2018, p.17).

Regarding jobs in the 4th IR, since 2000, technological change no longer correlates with the real wage growth of highly educated people. Beaudry, Green and Sand (2016) found that the demand for higher education skills increased only up to the year 2000, and then began to decline. In the context of a continuing increase in the supply of highly educated people, many high-skilled workers have been hired into jobs previously undertaken by lower-skilled workers. Under-utilization of skills therefore becomes both a personal and policy issue.

In summary, technological change has contributed to changes in the distribution of jobs. Some industries have grown while others contracted over time. The 3rd IR has encouraged the rapid expansion of more complex jobs for which there is demand for high education skills, but many routine jobs remain. Unskilled and routine jobs attract much less earnings over time, so that pay inequality according to job complexity has become a feature of the contemporary economy. However, the growth of high-skilled non-routine jobs plateaued in the 4th IR resulting in new problems. These considerations suggest two further important questions: does technological change lead to net unemployment and what effect does technological change have on economic inequality and the quality of jobs more generally?

Technological change and unemployment

Over the course of the three previous industrial revolutions the evidence suggests that technological change has led to the decline of some jobs and an increase in others. The net position varies between countries, periods, industries and jobs. But overall there is no evidence that technological change leads to net unemployment (Matuzeviciute, Butkus & Karaliute, 2017). In fact, some evidence suggests that innovation increases rather than decreases overall employment at the national level (Bogliacino, Piva, & Vivarelli, 2012; Coad & Rao, 2011; Vivarelli, 2014). Key factors include the demographic context, labour force characteristics and market dynamics. We will touch on these before considering some contemporary evidence regarding unemployment.

An economy experiencing rapid technological change might have a workforce that is expanding or contracting. For example, the proportion of non-working age persons relative to total population (the dependency ratio) between 1950 and 2010 in Europe and North America declined significantly. This would have increased the threat of technological unemployment as more persons would be eligible for work. However, for most of this period international trade increased and governments stimulated economic growth so that there was little evidence of technological unemployment. However, around 2012 the dependency ratio began to rise on account of population ageing and young persons remaining longer in education (Balliester & Elsheikhi, 2018, p.4) creating potential labour shortages and hence less vulnerability to technological displacement. This point underlines the proposition that the employment effects of technology cannot be understood, and by implication, predicted, without knowledge about population and labour force dynamics.

Additional workforce characteristics that need to be considered include the relative size of the informal economy, labour force participation rates and migration. The informal economy exceeds 30 percent in many developing countries and is growing in developed countries (ILO, 2016). This is a disincentive for introducing new technology, since wages are below the level that would prevail had employers and workers been paying taxes. The informal economy also perpetuates low job quality as employers seek to evade regulation. Regarding labour force participation rates, these vary between countries and between men and women. Where these are both high (e.g. Sweden), the impact of technological change will be more evident than where a large proportion of the workforce remains outside the formal workforce (e.g. Italy). Migrant numbers may vary according to government policy and will be perceived differently depending on the recent employment experience of local workers. Where immigration is tightly controlled (e.g. Japan) and the level of employment is moderate or low, workers will feel less threatened by technological change than where there is a labour surplus arising from large scale immigration and high unemployment (e.g. Greece).

Market dynamics are important in assessing the impact of technological change on unemployment. Economists have long discussed the market mechanisms through which the labour-saving effects of technological innovation are compensated by the creation of new jobs (Vivarelli, 2012). As discussed above, during the 1st and 2nd IR, the most notable job losses were in agriculture.

During the 3rd IR, most job losses occurred among routine jobs, both manual and low-skilled service jobs. In the 4th IR, relatively high-skilled blue collar (e.g. machine operators) and while-collar (bookkeepers and product testers) jobs are being reduced by new technology in advanced and developing economies (OECD, 2016). However, technological unemployment has been counter-balanced by the creation of new jobs and emergence of new industries.

At the firm level, new technologies can enable companies to increase employment. Firms taking advantage of labour-saving technologies will engage in both product and process innovation to improve productivity and profitability. Consequently, the adoption of new technology may improve market share and expand production so that the relationship between technological change and unemployment at the level of the firm may be inverse. Doms, Dunne, and Troske (1997) found that US factories are more likely to increase the overall employment when they introduce automating technologies.

At the industry level, higher productivity arising from technological change may lead to some job displacement. However, technological innovation has reduced the prices of product and services, which in turn has enhanced consumer demand thereby stimulating increased production and employment. Higher productivity arising from new technology can also increase wages as more skilled workers are required to operate and maintain digital machines. Higher wages have a secondary effect by increasing demand for particular goods whose prices has been stabilized or reduced, and so contributing to job generation. For example, the emergence of mass production technology in the early 20th century displaced some skilled production jobs in automobile and other consumer goods' manufacturing industries, however, the reduced price of automobiles and consumer capital goods such as fridges and washing machines, resulted in many new jobs in the automobile industry and in manufacturing more generally.

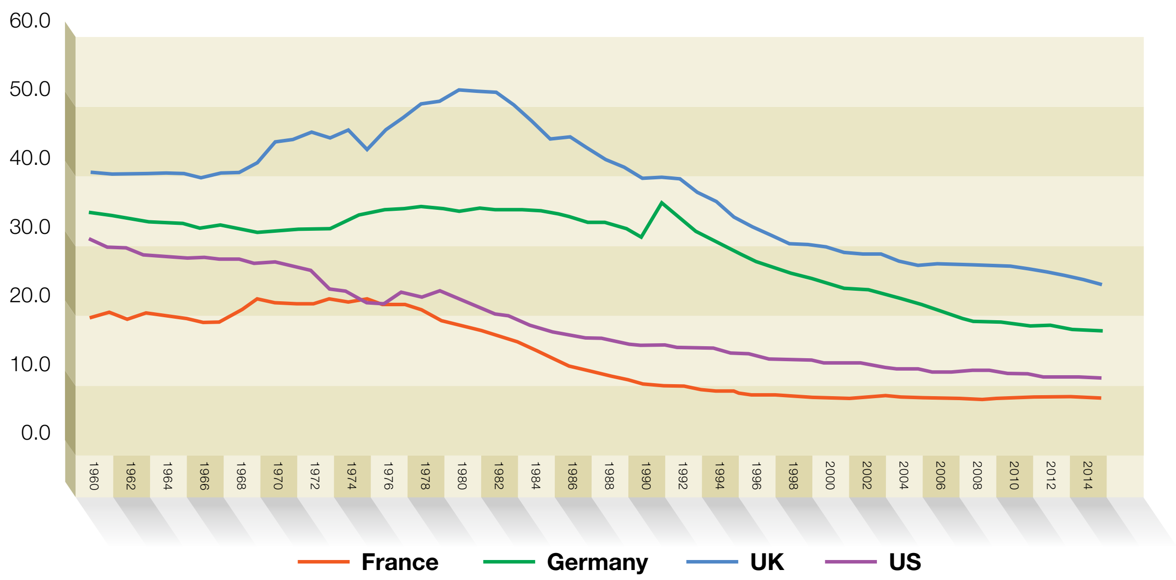
Finally, at the economy level, technological change has stimulated the emergence of new industries and created demand for new types of professional skills. For instance, the affordability of automobiles enabled the emergence of many new industries such as auto mechanics and travel-related services during the 20th century. More recently, digital technology eliminated some jobs while generating many new jobs. For instance, the emergence of video games negatively affected the toy industry leading to the closure of toy retailers such as Toys 'R' US. However, the video game industry has been expanding rapidly and now has more than 65,000 direct employees in the US (Siwek, 2017). Evidence from France indicates that over the past 15 years the internet destroyed 0.5 million jobs but created 1.2 million, thereby being a substantial net job generator (Bughin & Manyika, 2012). Similar job effects of technology are reported by Berger, Chen, and Frey (2016) while Mann and Puttmann (2017) show that new technology leads to net gains in local labour markets. Estevadeordal et al. (2017) show that although industrial robots have been growing at 17 percent a year since 2010, these are utilized in only five countries so their employment effects are unlikely to be substantial. Evidence from executive surveys concerning the employment effects of technological change indicate that managers are more likely to report job creation rather than job destruction (Balliester & Elsheiki, 2018, p.14) leading the authors to conclude that "… while manufacturing employment tends to decline in response to automation, these effects are far outweighed by service sector job growth." (p.15).

Technological change, economic inequality and job quality

A feature of the contemporary economy is the increasing returns to capital arising from technology. This is indicated by the share of national income going to capital as compared to labour. In 1970, capital's share of national income for advanced economies was 45.5 percent, increasing to 60.5 percent in 2014. The corresponding figures for labour's income share are 54.5 percent and 39.5 percent respectively;[1] four-fifths of the decline in labour's share of national income between 1990 and 2007 can be explained by technology. The 4th IR has witnessed the growth of large technology-based firms such as Google, Facebook, Amazon and Apple which appropriate most of the profits in the sectors in which they operate. According to the Economist (2016), 10 percent of the world's public companies account for 80 percent of aggregate profits (Balliester & Elsheikhi, 2018, p.27). Therefore, it is not surprising that revenue generated by these and related firms are accounting for a larger proportion of national income, particularly in view of workers' reduced bargaining power as noted below.

There is considerable evidence that new technology has facilitated the routinisation of jobs in manufacturing and services. Accordingly, there is less of a premium on scarce skills. This is no different to the past, except that during the 2nd IR, especially between 1950 and 1970, unions, sometimes with the help of the state, were able to negotiate acceptable pay and conditions for members and non-members alike, through collective bargaining. In the 3rd IR, unions in advanced countries lost ground. Figure 4 shows union density (proportion of union members relative to the workforce) since the beginning of the 2nd IR.

Figure 4: Trade union density, selected countries, 1960-2014



Source: OECD database.

[1] A decline in labour's share of national income has also been a feature of emerging market and developing countries. In 1995 labour's share was 50.5 percent in 1993 declining to 37.4 percent in 2014 (Balliester & Elsheikhi, 2018, p.28)

With declining union density, unions have been unable to bargain effectively with employers and governments have tended to pursue neo-liberal policies, by and large leaving employers and the market to determine pay and working conditions. On the other hand, employers facing skilled labour shortages have enabled so-called knowledge workers to secure higher pay and better conditions of work.

A feature of the 4th IR is that routine workers have experienced deteriorating job quality regardless of technological change. This is the consequence of employers' seeking labour market flexibility by favouring non-standard forms of employment, including temporary, part-time, and self-employed work and short-term agency work. These flexible forms of employment give rise to insecurity and feelings of precariousness. A second more recent feature is based on the internet. It is the platform, gig or sharing economy which encourages short-term work, particularly 'free-lancing' based on self-employment. An estimated 25 percent of the US workforce are self-employed, although the platform economy only accounts for about 4 percent of total employment in the US and UK (Balliester & Elsheikhi 2018, p.18-19). Nevertheless, the platform economy accounts for most employment growth over the last decade (Friedman, 2014). According to a large-scale study, platform economy participants are engaged in low quality jobs characterized by declining earnings, high labour turnover, discrimination based on gender and ethnicity, and inadequate procedures for conflict resolution (Balliester & Elsheikhi, 2018, p.19).

In summary, since the 18th century western countries have continuously experienced technological change and at particular junctures, these have been far-reaching and disruptive, job destroying but also job creating. New technology is part of a wider economic process that in the main has served society well by generating economic growth. Overall, there is no evidence that technological change causes net unemployment at the macro level. We noted that the impact of technological change depends on demographic and workforce characteristics. Regarding job quality, there is evidence for polarisation: knowledge workers have received much more favourable pay and conditions than routine manufacturing and service employees whose work has become less secure as the informal economy and non-standard work expand.

Diverse experiences of technological change across Western countries

Thus far we have implied that the experience of technological change has been similar across Western countries. However, the importance of various types of change vary according to the characteristics of economies. Hall and Soskice (2001) distinguished between liberal market economies (LMEs) exemplified by the US and UK, and coordinated market economies (CMEs) such as Germany and Sweden. In LMEs, companies organize their activities primarily through competitive market mechanisms, and the government does not directly intervene in the private sector. In contrast, companies in CMEs depend more on government cooperation with firms and trade unions. The authors argued that LMEs were better suited to radical or break-through innovation based on high-technology industries while CMEs were stronger on incremental innovation as in mechanical engineering (Hall & Soskice, 2001). In other words, countries tend to specialize in different types of innovation according to the comparative advantage conferred by their political economic system.

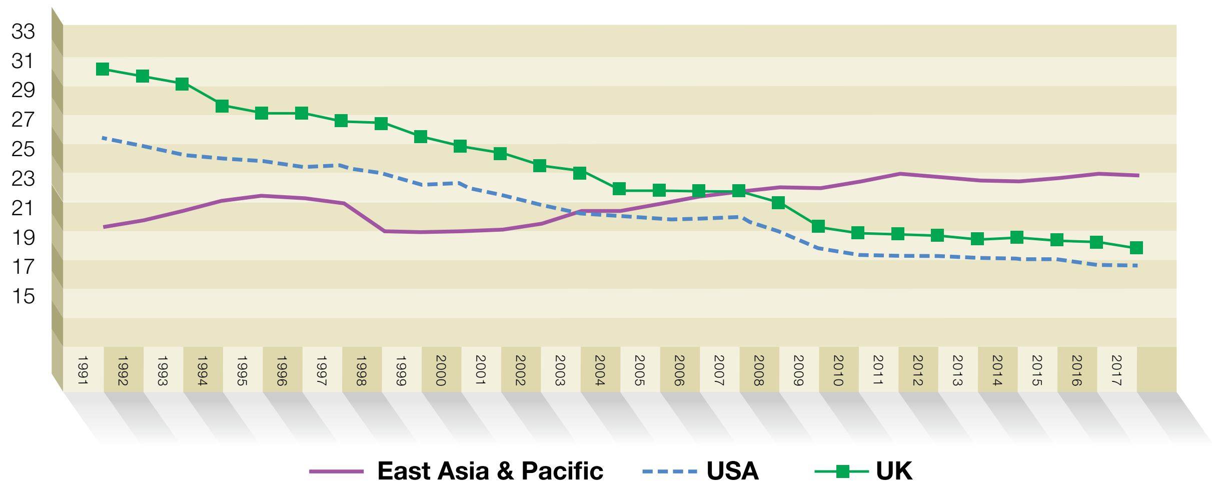
This view has been questioned. Akkermans, Castaldi, and Los (2009) have argued that although the two types of economy have different strengths, different kinds of high-tech industries can prosper in the two types of systems. Specifically, they found that LMEs tend to excel in radical innovations in chemical related industries and electronics while CMEs excel in radical innovation in the machinery and transport equipment industries. More recently, Hotho (2014) has suggested that there is no one best institutional recipe for technological innovation. Examining innovations in biotechnology, nanotechnology and information technology in 30 OECD countries from 2000 to 2011, he found that technological innovation can be facilitated not only by a typical liberal market arrangement, but also by other institutional formations, especially those with equitable educational systems accompanied by less burdensome control of economic activity. In summary, LMEs and CMEs have developed different technological specializations, but no one pathway to technological innovation is necessarily superior to the other.

Having reviewed evidence based on Western country experience, we now turn our attention to the Asia-Pacific region where industrialization has occurred under different cultural, institutional and economic circumstances.

Technological change and employment in the Asia-Pacific region

The technological changes that fuelled industrialisation in the Asia-Pacific region differed from the West in three main ways. First, industrialization, often accompanied by rapid economic growth, occurred mainly after the Second World War (post-1945). Australia and New Zealand developed earlier under tariff protection while Japan rapidly industrialized based on export-oriented industrialization. South Korea, Taiwan, Singapore and Hong Kong followed, and more recently Asian nations including India and China have begun to catch up (World Bank, 2002). Second, over the last four decades employment in Asia-Pacific countries grew steadily based on labour-intensive manufacturing. Figure 5 shows the contrast with the US and UK based on the proportion of employment in manufacturing. This represents a major geographical movement of manufacturing to Asia reflecting lower unit costs but also reduced costs of transportation and communication which favoured the growth of global supply chains. Significant Asian global manufacturing companies including Sony (Japanese), Samsung (Korean), Asus (Taiwanese) and Huawei (China) arose from this relocation of production. This also occurred in services as highlighted by the scale of Hong Kong-based logistics company JSI Hong Kong, and supply chain services provider, Li and Fung, and Indian computer service providers Infosys and Wipro.

Figure 5: Percentage of employment in manufacturing by selected region and countries, 1991-2017



Source: Data from https://data.worldbank.org

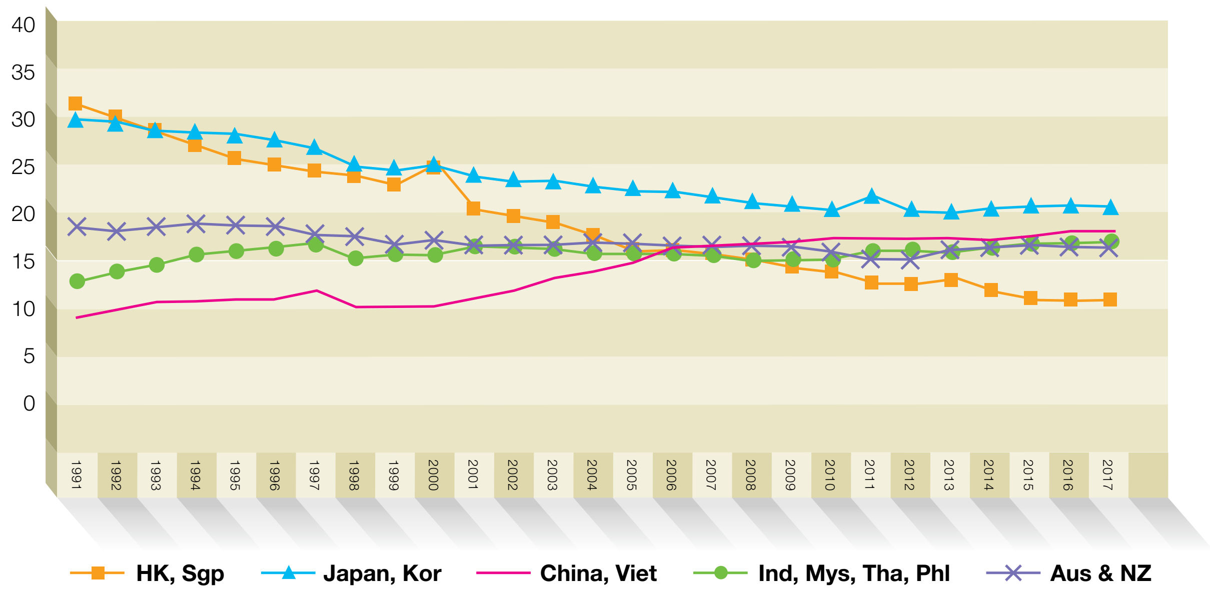
A third feature of Asia-Pacific countries has been the leading role played by the state. South and East Asian countries have developed national business systems in which governments play a dominant role in economic development, including promotion of technological change (Whitley, 1999; Witt & Redding, 2013).

It can be argued that contemporary Asian economies may be more vulnerable to technology-induced job destruction than Western countries. This is because of the relatively high proportion of semi-skilled manufacturing and routine service jobs in these economies that are more amenable to automation. The history of technological change and employment suggests otherwise and there are additional reasons for scepticism. According to ADB (2018), labour-saving technology may not always be economically feasible. The introduction and maintenance of automated systems often requires substantial investments that may not be justified in a context where labour is relatively inexpensive. Where new technology is introduced, job destruction is not the only impact. Additional workers will probably be needed to maintain the new technology and productivity effects that are realized through improvements in market share may lead the firm to hiring more employees (Autor & Salomons, 2017). This market expanding effect may be very large where firms are able to compete successfully in export markets or where domestic demand is growing rapidly. The demand for digital devices across the world has boosted employment in electronics manufacturing, where supply chains stretch across several countries, ultimately finishing in China, where many products are assembled. Services are also part of this same dynamic as illustrated by the success of information technology applications in the Philippines (call centres) and India (software development and consulting services).

Differences between Asia-Pacific countries

Thus far we have only hinted at differences between countries in the Asia-Pacific region. Because industrialization occurred in different periods these countries exist at different stages of development. This is reflected in manufacturing employment data shown in Figure 6. The early industrializers – Australia, Japan, Korea, Taiwan and Singapore – have experienced a substantial reduction in manufacturing employment having transitioned into post-industrial societies, while late successful industrializers such as Vietnam, China, and Indonesia show substantial growth in manufacturing employment. India, Malaysia, Thailand and the Philippines have been slower to industrialize as shown in the relatively stable manufacturing employment trends illustrated in Figure 6.

Figure 6: Manufacturing employment as percent of total employment by selected country, 1991-2017



Source: Data from https://data.worldbank.org

A second important difference is the role of the state. While adopting a more prominent role than in most Western countries, there are noteworthy differences within the region, including different approaches to technological change and support for employment creation. Table 2 summarizes some of these national differences over the last four decades, including national governments responses to the challenges of the 4th IR.

Table 2: Types of Asia-Pacific economies, the state, technological change and employment

Selected Countries	Institutional arrangements. Role of the state	Changes in employment structure since the 1980s	Government involvement in policy relating to new technology
Australia, NZ	- Liberal market economy - Arms' length relationship between economic actors - Regulatory	- Generally small changes in employment structure - Dominant service sector - Small, stable manufacturing sector	- Job creation by reducing regulatory risks for high tech industry such as Fintech - Late effort to improve internet environment through NBN Co., a government-owned monopoly - Tax incentives for R&D activities
S. Korea, Japan, Taiwan	- Plutocratic State-led Capitalism - Developmental / Regulatory - Family-owned conglomerates dominate the economy	- Moderately declining manufacturing employment but remains significant - Low agricultural employment - Growing service sector	- 'Cyber Korea 21' initiative (1999-2002) that resulted in the world's highest internet penetration rate in 2001 - Government coordinated stakeholders in internet market (service providers, hardware device manufacturers, and customers). - Maintaining manufacturing employment with smart factory initiatives - Substantial government spending on SMEs with the aim of diffusing smart factory technologies
Singapore, Hong Kong	- Open State-led capitalism - Hybrid authoritarianism and democracy - Open to global economy - Regulatory	- Substantial decline of manufacturing and growth of services - Low agricultural employment - Large foreign workforce	- Many high-tech companies - Regulatory relaxation and job creation by fostering advanced innovation - Government funding of SMEs under 'Go Digital programme'
China, Vietnam	- State capitalism - Communist Party dominates within market system - Developmental	- Rapid growth of manufacturing employment - Declining but still important agricultural employment - Service work is growing	- Broadband service market is dominated by two state-owned firms (China Telecom and China Netcom). - 'Made in China 2025' initiative to technologically upgrade manufacturing industry - 'Great Firewall of China', extensive government effort to control potential threat of open access to internet - Upgrading quality of manufacturing jobs
Malaysia, Indonesia, Philippines	- Personal capitalism - Concentrated enterprise ownerships - Personalism often dictates business decisions and transactions - Predatory / developmental	- Low and largely stable manufacturing employment - Declining but still substantial agricultural employment - Growing service sector	- Broadband infrastructure building and upgrading are conducted by government-linked companies. - Bold initiatives by govts., however, few indications of success (Carney & Andriesse, 2014)

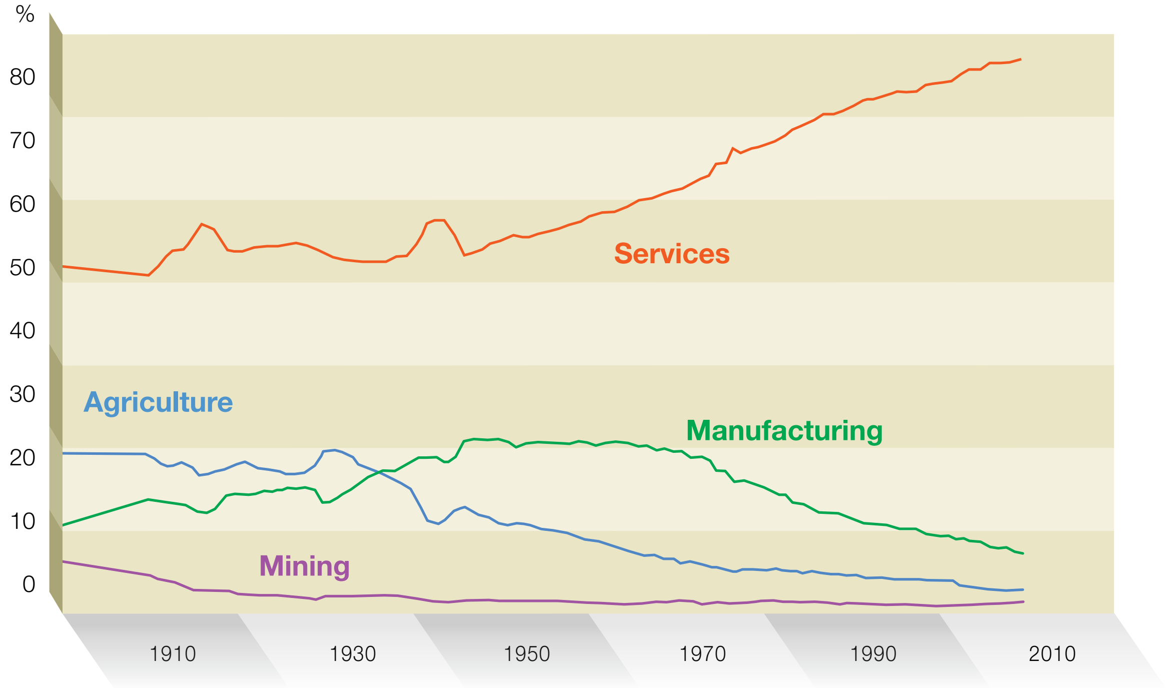
Source: the authors.

Note: Columns 3 and 4 refer to the country in bold

Australia

Australia is a liberal market economy administered by federal and state governments with economic actors having arm's length relationships with one another. Governments tend to minimize direct involvement in business activities, preferring instead to stimulate innovation by providing incentives to firms. According to a recent federal government statement: "The underlying policy should continue to focus on creating a macroeconomic environment conducive to innovation and growth by improving framework conditions" (Federal Department of Industry, Innovation and Science, 2017, p.86). Like other advanced market economies, Australia experienced the 3rd IR with a low proportion of the workforce engaged in manufacturing (less than 20% by the 1980s), entering the 4th IR with service employment in 2000 exceeding 80 percent as shown in Figure 7.

Figure 7: Employment share in percent by industry, Australia, 1900-2010



Source: Connolly & Lewis (2010)

In lieu of a deep, systematic approach to national innovation, Australian governments combine various macro and micro economic policies to resolve problems that inhibit technological change and restrict economic growth. As summarized in Table 3, the current agenda comprises four problem-areas that address various policy issues with specific policy interventions.

Table 3: Australia's approach to innovation, 2015-18

Problem-area	Policy issue	Policy intervention
Culture and capital	Innovative ideas insufficiently leveraged by companies	Various tax, accounting and legal changes to encourage start-ups and risk-taking. Some direct investment by government in applied research
Collaboration between researchers and companies	Too limited	Increased research grants for collaboration; more investment in research infrastructure
Talent and skills	Insufficient science, technology, engineering and maths (STEM) students; talent shortages in key areas	Increased investment in STEM education and revise visa system
Government	Co-ordination of innovation needs improving; insufficient digitalization of services	Establishment of statutory board to co-ordinate policies affecting innovation. New Digital Transformation Office to promote public service digitization

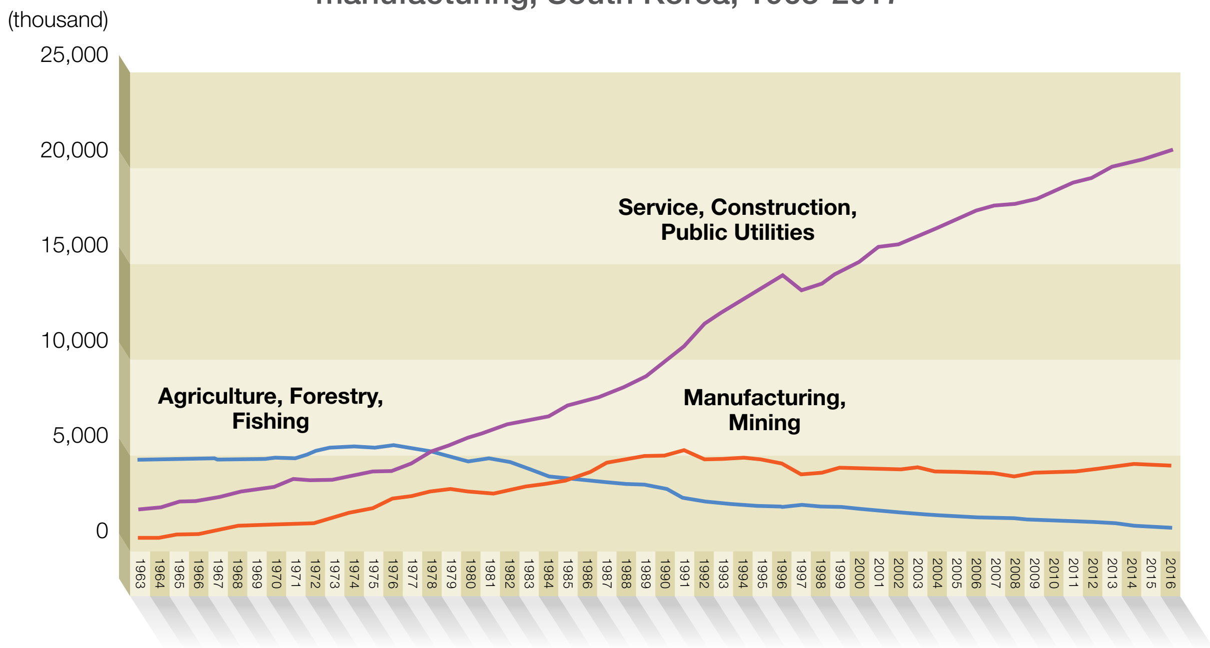
Source: Australian Government, 2015 https://www.industry.gov.au/national-innovation-and-science-agenda-report

Although there are few direct references to technology, the federal government has been active in promoting the FinTech industry described in the vignette section below and state governments have been enhancing the digitalization of mining technology by supporting local educational institutions in providing nationally recognized vocational training. This scheme aims to ensure that the workforce has the necessary skills for undertaking work in a highly automated environment where half the mining workforce is likely to be replaced by robots by 2020 (McHugh, 2017).

South Korea

Over the last half century, Korea experienced substantial change in its employment structure. In the 1960s, Korea was an underdeveloped country with over 60 percent of employment in agriculture, forestry and fishing. In the 2000s, agricultural employment comprised less than 10 percent of total employment while service sector employment accounted for more than 70 percent of total employment. As shown in Figure 8, manufacturing employment grew substantially between the 1960s and late 1980s, and then continuously declined as component production and assembly were outsourced to facilities mainly in China, Vietnam, and Indonesia. Nevertheless, complex manufacturing remains a significant source of employment. Although Korea's pattern of employment change has resembled that of many Western countries, Korea's experience has been more recent and much faster, spanning 50 years compared to Western countries where the transition lasted around 200 years.

Figure 8: Employment share in percent by industry, and workforce in mining and manufacturing, South Korea, 1963-2017

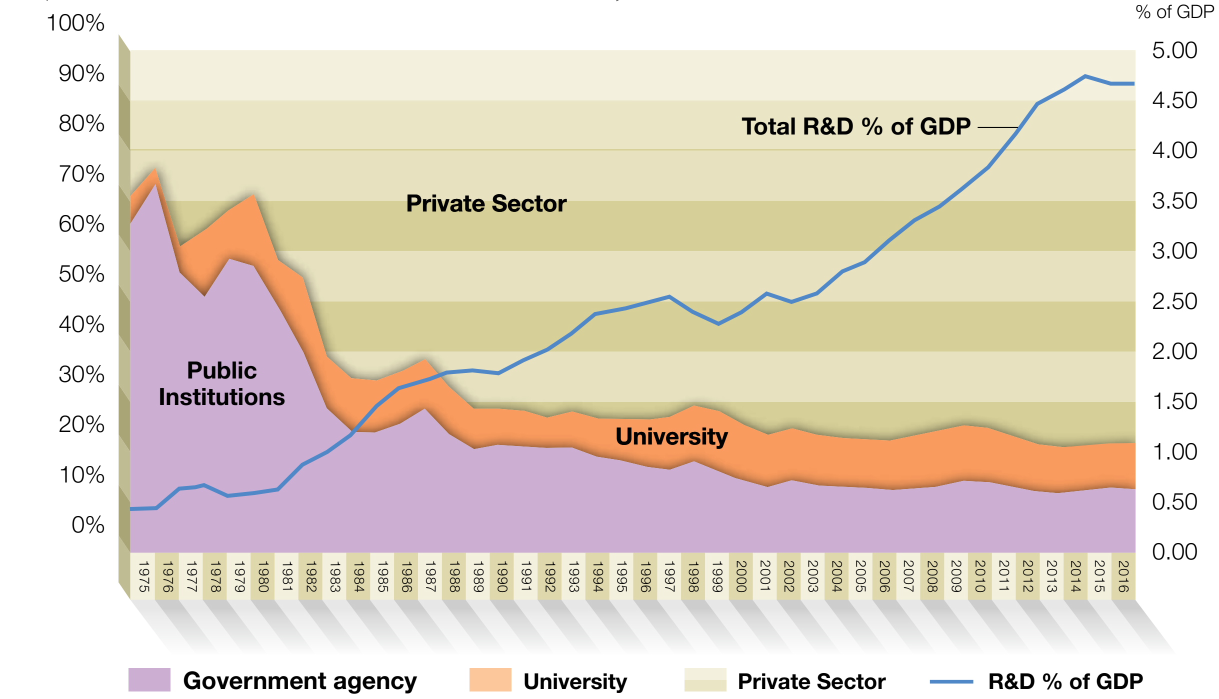


Source: Data from Korean Statistical Information Service of Statistics (accessed through http://kosis.kr). Adapted from Koo (2013)

Traditionally, the Korean government has actively guided economic development. It has had a strong influence on private enterprises, especially the large family-owned, Chaebol conglomerates. Technological change has been strongly encouraged by the government, particularly during the early stages of economic development. In the 1970s, the government established many government-funded research institutions including Korea Advanced Science and Technology

(KAIST), Korea Institute of Machinery and Metals (KIMM), the Electronics and Telecommunications Research Institute (ETRI), the Korea Research Institute of Chemical Technology (KRICT), the Korea Institute for Energy Research (KIER), and the Korea Ocean R&D Institute (KORDI). As shown in Figure 9, until the early 1980s, R&D investment activity was dominated by publicly funded research institutions.

Figure 9: Sources of R&D expenditure, South Korea, 1975-2016



Data from e-NaRaJiPyo service by Korea Statistics (accessed through http://www.index.go.kr). Adapted from Koo (2013)

The direct involvement of government in technological change has continuously declined over the last three decades. Since the 1997-98 Asian financial crisis the government began to coordinate rather than directly develop new technology. This transition has been largely successful, evidenced by many Korean companies, especially Chaebols such as Samsung and LG organising their own R&D activity and emerging as high-technology multinational corporations. The Korean government has also succeeded in encouraging companies and customers to embrace new automation and communication technologies. The government initiated smart factory support schemes enabling hundreds of small and medium sized manufacturing companies to receive financial support for upgrading their manufacturing processes, equipment, and human resources. Currently, Korea has the highest rate of industrial robot density in the world (McCarthy, 2018). Korea is also the world leader in broadband speed (Chong, 2018).

Singapore

Singapore's economy is a form of state-led, open market capitalism. Singapore experienced a dramatic reduction in manufacturing employment over the last three decades mainly because of China's expansion as an offshoring centre for Western manufacturing. In Singapore global markets shape economic activity. However, the government plays a major role in the development and diffusion of technology. In 2015, the Future of Manufacturing Initiative was introduced under the government's Research, Innovation & Enterprise 2020 plan. This included extensive engagement with industry and the trade associations (A*STAR, 2018). The goal is to sustain Singapore's manufacturing competitiveness maintaining its position as a location of choice for introducing advanced technologies. The initiative comprises three aspects: a public-private partnership platform enabling access to new technology (Tech Access); a site (Tech Depot) that offers SMEs a suite of easy-to-use technologies that can help SMEs to improve productivity; and opportunities for managers to visit factories (currently there are two) using advanced technology (Model Factories).

The investment arm of the Singapore government is Temasek Holdings which owns a 52 percent share of SingTel, the dominant internet service provider in Singapore and a 100 percent share of ST Telemedia, an investment company specializing in the high-technology sector. ST Telemedia owns shares in many technology start-ups such as Bespin Global, a cloud management company. In addition, the government drives innovation by providing direct financial support to SMEs for digitization. In 2017, the government confirmed its intention to spend S$2.4 billion (1.7 billion USD) over the next four years in supporting "go-digital" initiatives. In the same year, the government launched a new skills framework for ICT talent and provided consultancy services to companies for developing technology workers (Mui, 2017). The government is also facilitating the FinTech industry as indicated below.

China

China is the largest emerging economy. It is dominated by a one-party State that encourages market forces. Labour-intensive manufacturing employment has been growing rapidly while the workforce employed in agriculture has been declining but nevertheless remains substantial. The proportion of the workforce employed in the service sector is expanding but remains lower than many industrialized countries. Although declining, a high proportion of workers are employed under 'informal' employment arrangements that remain largely outside the law.

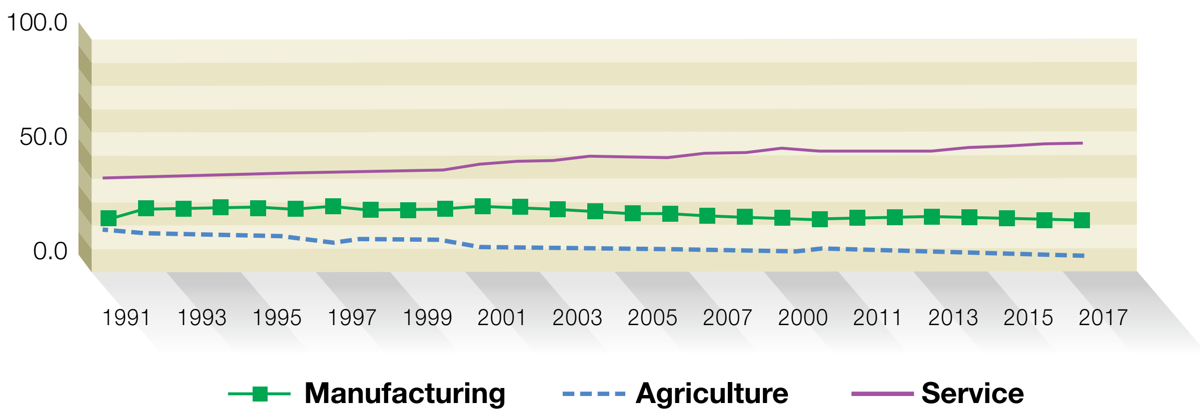
Economic growth has resulted from mainly Western countries embarking on the computer-based, 3rd IR. Digital technologies and new communication media contributed to the emergence of global supply chains and the offshoring of manufacturing to China. As the global market for digital devices increased significantly, so did production by firms based in China, some of which were foreign-owned, others owned mainly by Chinese private investors or the State in industries considered strategically important. State-owned firms therefore continue to dominate technology-oriented sectors. An example being China's broadband internet service market which is controlled by two state-owned firms, China Telecom and China Netcom. The venture-capital sector in China is also controlled by the state. It is estimated that more than 1,000 venture-capital firms in China are owned by the government (Balding, 2018). Recently, China has emerged as the fastest growing market for industrial robots. Under the rubric of 'Made in China 2025', the government has initiated many programs to technologically upgrade manufacturing industry.

A distinctive feature of the Chinese government's approach to new internet technology is its effort to establish and maintain the 'Great Firewall of China'. This includes the application of extensive censoring of internet traffic intended to control the political environment but also serving as a mechanism to protect and nurture Chinese technology companies. By blocking or placing onerous conditions on the entry and operation of Western online services such as Facebook and Google, similar domestic technology services such as Weibo and Baidu have benefitted by being able to develop in the Chinese market, providing a platform for international growth.

Malaysia

The institutional arrangement of Malaysia can be categorized as 'personal capitalism' where personal connections play a major role in business transactions. The emphasis on personal connections undermines the overall transparency of business systems. This is reflected in the country's high corruption score. According to Transparency International (2018), Malaysia ranked 62 out of 180 in the 2018 Corruption Perception Index, declining from 55th place in 2016. Nevertheless, Malaysia has maintained a 6.4 percent average annual growth rate since 1970. Over the last three decades, the most noteworthy change in its employment structure has been the growth of the service sector. Despite government efforts, the manufacturing sector has failed to imitate Singapore and Vietnam's success.

Figure 10: Employment by sector, Malaysia, 1991-2017



Source: Data compiled from World Bank Open Data (https://data.worldbank.org)

Successive governments have proposed bold initiatives, such as a national information technology agenda and plans to establish a biotechnology industry. However, there are few indications of success (Carney & Andriesse, 2014), a notable exception being the National Broadband Initiative program described below. The project dramatically increased the broadband penetration rate from less than 20 percent in 2007 to over 70 percent by 2015. Recently, the Malaysian government has begun to work with Broadnet, a government owned company to further upgrade the speed of broadband network.

As noted above, governments in the Asia-Pacific region are interested in promoting the adoption of new technology, however, they vary in both the importance attached to this and the manner in which it is supported. At one extreme is Singapore whose policy-making sees the adoption of new technology as a matter of survival while at the other extreme, for example, Thailand views it as a useful tool for improving competitiveness and maintaining national pride. In some countries the government plays a central role – for example, China's pursuit of renewable energy sources, which includes construction of markets and subsidies for firms engaged in adopting these innovations – while in others, the government restricts itself to seeking to provide a favourable environment for the adoption of new technology. Overall however, all governments realize that new technology has to be adopted in order to retain competitiveness and that harmful effects can be mitigated.

Technological change at the industry and firm levels

A more detailed picture of technological change and its likely effects at the industry and firm levels can be obtained from four vignettes of technological change that have recently been implemented or are currently underway. These examples highlight the application of digital technologies in manufacturing, biomedicine, finance and the internet sector respectively. Data limitations have restricted our assessment of the employment and job quality consequences of these new technologies.

Manufacturing: smart factories initiatives in Asia

Beginning in 2014, the South Korean government has actively supported the digitization of small and medium sized manufacturing companies under the rubric: "Manufacturing Industry Innovation 3.0". By 2017, the government supported about 5,000 factories, spending over $100 million on the program. Eligible companies can apply for grants for innovation projects such as introducing a cloud-based system to monitor and control manufacturing processes. According to Kim and Lee (2016) who surveyed 400 participating factories, the average firm reported a productivity gain of over 23 percent following introduction of new technology. The authors reported that digitization did not reduce employment in these factories and that employees' job satisfaction had increased appreciably. Furthermore, they suggested that the net impact of factory digitization on employment was positive as it increased employment in digital service technology companies.

In Singapore, the government has been developing and diffusing smart factory technologies. In 2015, the Science, Technology and Research (A*STAR) Agency launched a Future of Manufacturing Initiative which involved the Singaporean government choosing several model factories and co-developing new smart factory technologies with the management. The government also provides small and medium-sized firms with various services to ensure their access to cutting-edge smart factory solutions. The government is also engaged in introducing various initiatives aimed at assisting employees to widen and deepen their skills. The Professional Conversion Program (PCP) aims to help mid-career managers upgrade and broaden their skills to fit new job opportunities.

China recently launched a national smart factory initiative under the slogan "Made in China 2025". The total estimated funding for the program will exceed 1.5 billion US dollars. In 2018, the Chinese government is supporting 100 pilot projects, aimed at substantially increasing manufacturing productivity. The government claims that the pilot projects have been very successful, showing productivity gains of more than 30 percent. The employment consequences of these projects are unclear. There is some concern regarding job destruction as evidenced by the claim that over the 2014-16 period 87,000 jobs in the Southern industrial city of Dongguan are likely to have been replaced by industrial robots (Yang, 2017). Against this is evidence that overall manufacturing employment in China has been growing steadily in recent years, despite the introduction of industrial robots and other forms of automation.

In Japan, the government introduced the “Robot Revolution Initiative” in May, 2015. Currently the program includes about 500 member companies/associations. As leaders in high-tech manufacturing, Japanese companies are promoting their capabilities as vendors of smart factory solutions. In 2017, a group of Japanese companies including Fujitsu and NEC founded the Flexible Factory Partner Alliance (FFPA) to create more compatible smart factory solutions that will strengthen these firms’ competitiveness in world markets. Japanese smart factory solution providers are also building collaborative networks with technology companies in other countries. For instance, Toshiba signed a deal with Huawei on a joint project to promote smart factory solutions while Fujitsu established a joint venture with a Chinese state-owned firm to provide smart factory solutions to Chinese manufacturing companies.

In Taiwan, Foxconn is leading the transition towards smart factory innovation. In February 2018, the company announced that its Taiwanese LED panel factory will automate 75 percent of the manufacturing process thereby replacing 10,000 employees with robots by the end of the year (Fearn, 2018). At the same time, Foxconn also announced that the company plans to invest $342 million in artificial-intelligence based manufacturing technologies over the next five years, including hiring top talent to ensure success (Lomas, 2018).

Biomedicine: Singapore’s big push

In the 1980s Singapore began pursuing a national innovation strategy comprising electronics, precision engineering and chemicals, aimed at creating a knowledge-based economy. Emphasis was on the co-evolution of industry and the state with the state controlling industry and innovation (Parayil, 2005). In the late 1990s, biomedical sciences were identified as a fourth innovation pillar that would differentiate Singapore from other countries evolving into knowledge-intensive economies. Government strategy changed in two main ways: universities and research institutes were included in the innovation framework and there was a retreat from direct control to permitting the partners more autonomy in policy-making, albeit guided by the government. A defining feature of Singapore’s biomedicine approach has been to create clusters in pharmaceuticals, biotechnology, medical technology, and health care services rather than concentrating on one or two links in the supply chain. This concurrent approach has included attracting multinational companies and encouraging start-up firms.

Beginning in 2001, the government invested heavily in building core biomedical scientific research capabilities by pursuing favourable educational, training and tax policies. Between 2006 and 2010, 25.3 percent of the government’s $13.5 billion R&D expenditure was spent on biomedical sciences contributing around 3 percent of GDP. Considerable investment has been made in attracting and developing skilled personnel as a contribution to developing a world-class biomedical hub, an example being the Bioprocess Internship Program which prepares science and engineering graduates for careers in bioprocessing. Commentators agree that Singapore's biomedicine initiative has so far succeeded. One indicator is private/public R&D investment. In 2000, prior to the strategy being implemented, the private sector invested about 15 percent less than the public sector. By 2008, private-sector investment was over twice as much. Furthermore, over 100 global biomedical firms have research and/or manufacturing facilities in Singapore and according to a recent report (Today, 2018)[2], the number of biotech start-up firms has more than doubled in the last six years to about 50, contributing to a sevenfold increase in R&D expenditure. Regarding output, biomedical manufacturing in Singapore increased 44.9 percent in 2016 (The Pharmaletter, 2017)[3] and Singapore increased its share of the world's patents from 0.2 percent in 2000 to 0.8 percent in 2014 (OECD, 2015).[4] According to Poh (2010), Singapore's success in biomedicine has resulted from government commitment to R&D, an integrated and strongly networked public sector, public-sector research institutes that engage in both basic and targeted applied R&D to develop a spectrum of capabilities, an educated and skilled workforce, and a supportive business and regulatory environment.

Finance: the emergence of FinTech in the Asia-Pacific region

Digital technology is radically reshaping finance industry operations and employment. Traditional banking and finance institutions have experienced low profitability and consequently have been encouraged to reduce employment. For example, in Korea, total employment in the finance sector went down by 14,000 persons in 2017. In Japan, the Mizuho group, which is one of Japan's three megabanks, recently announced the introduction of AI systems which are likely to reduce the company's 60,000 positions by 19,000 in the next ten years. In Australia, NAB, one of the country's four largest banks, announced that the company will shed 6,000 jobs by 2020 as a result of automation.

Although employment in established financial companies is shrinking, this is likely to be partly or wholly offset by the emergence of the FinTech sector. FinTech refers to alternative financial services enabled by modern digital technologies (Finance + Technology). It includes a range of new services and technologies such as the blockchain digital ledger, crypto currencies, peer-to-peer lending, and robotic investment advice systems. FinTech is growing rapidly in the Asia-Pacific region, particularly in Australia and Singapore. According to a KPMG report (2017), the industry in Australia now employs more than 10,000 people. In Singapore, the government is implementing ambitious plans to position the country as a global hub for the FinTech industry, facilitating the supply of more than 4,000 FinTech experts annually.

The emergence of new technology provides both opportunities and challenges for regulatory authorities. In 2016, governments in Singapore and Australia introduced the 'regulatory sandbox' concept to enable financial service innovation to proceed unimpeded by excessive regulations.

[2] https://www.todayonline.com/singapore/surge-local-biotech-scene-public-investments-pay
[3] https://www.thepharmaletter.com/article/singapore-s-biomedical-manufacturing-output-leaps-45-in-december
[4] http://www.oecd.org/innovation/inno/keybiotechnologyindicators.htm

The regulatory sandbox was first introduced in the UK in 2015 as a mechanism to encourage FinTech companies to experiment with innovative services by eliminating regulatory uncertainty. Inspired by this innovation, the Singapore government introduced a similar system, allowing relevant FinTech companies to claim temporary exemption from existing regulations and licensing requirements. Similarly, the Australian Securities and Investments Commission (ASIC) introduced a waver scheme to allow FinTech businesses to test certain specified services for up to 12 months without an Australian financial services or credit licence (ASIC, 2018).

The technological changes described above indicate far-reaching changes whose organisational and employment consequences are difficult to envisage but are worth studying on an ongoing basis.

Broadband infrastructure: Asia-Pacific roll-out with special reference to Malaysia

Broadband is a transmission technology for internet communication. It permits internet service providers to sell internet use to consumers. It has been introduced on a national basis in the Asia-Pacific region using broadly similar technology but with different objectives and subject to varying regulatory regimes differ. Table 4 provides a summary.

Table 4: Introduction of Broadband technology, Singapore, Malaysia and Australia

Country	ICT policy framework	Key objectives	Current or new partnership	Outcomes
Singapore	Next generation NBN	Connect 100% population to high speed broadband	2 new entities	Achieved in 2013
Malaysia	NBN initiative - HSBB	Connect 75% of population by 2015, remainder ongoing	Public-corporate partnership	Successful deployment
Australia	NBN	Connect 93% of the population to broadband	New public entity and public-private partnerships	Construction and deployment ongoing

Source: adapted from ITU, 2016: 49
Note: NBN refers to National Broadband.

Table 4 shows that Singapore has been most successful in deploying broadband technology, having achieved 100 percent high speed penetration in 2013. Malaysia has recently succeeded in implementing broadband to 75 percent of the population while Australia has only achieved around one third penetration [5].

The ITU has identified the Malaysian initiative as ‘best practice’ on the basis that it was introduced rapidly to a comparatively large number of customers in a cost-effective manner. The project was undertaken by a partnership between Telekom Malaysia (a public company linked to the Government) and the Malaysian Government. It is central to the government’s objective of establishing a knowledge-based society that will overcome the digital divide that was emerging prior to completion of the broadband initiative. In addition, the government anticipates job creation and improved management efficiency arising from increased internet usage linked to the broadband initiative (ITU, 2016).

A review of research on the economic impact of broadband more generally indicates four main effects: it contributes to economic growth; it increases organisational productivity subject to a lag as business processes take time to change; it increases job growth both directly via construction and implementation processes and by encouraging adoption of broadband-based services in the areas of health and entertainment, finance, education and health care (Katz, 2012, p.17; Ghosh, 2017).

[5] The rollout of the nbn™ access network is now more than halfway built with around one in three Australian homes and businesses already connected. NBN Co remains on track to complete the rollout of the network and connect eight million homes and businesses by the end of 2020.
https://www.nbnco.com.au/content/dam/nbnco/media-releases/media-release-customer-experience-progress-report.pdf

Public policy implications

As highlighted above, national governments in the Asia-Pacific region have made efforts to facilitate technology-based economic growth while minimizing its negative impact on employment. Their experiences provide several valuable lessons.

First, Asian experiences of technological development highlight the importance of public policy in the development of technology and promotion of economic competitiveness. The rapid economic transformation of key Asian countries including Japan, Korea, Singapore, and China demonstrate that successful transformation from agricultural societies has been facilitated by distinctive national governmental innovation systems.

Second, the Asian experience of technological change differs depending on context. As depicted above, the Asian experience is more recent and therefore quite different from the West. And within the Asia-Pacific region, no two experiences of technological change are the same. The success of a policy in one country is unlikely to guarantee the success in other countries. Government policy needs to be tailored to those aspects of the material, cultural and institutional context that are most likely to provide comparative advantage. For instance, government support for different kinds of smart manufacturing technologies may be appropriate for Korea and Japan but not for Malaysia and Cambodia where manufacturing is less developed. Another example is the FinTech industry, which was shown to be effective in common law countries such as Singapore and Australia, but not in civil law countries such as Korea. Singapore's impressive development of the biomedical industry builds on that country's reputation as a safe, dependable, efficient and relatively low tax investment centre for MNCs that is difficult to replicate in other countries while the central government's involvement in building affordable and accessible broadband networks in Malaysia contrasted with the Australian experience where the government preferred combining limited government intervention with market competition. Policy makers need to understand the unique strengths and weaknesses of their country's institutional arrangements in order to develop policies that will succeed in global markets.

Third, Asia-Pacific regional and national policy-makers need to address the negative impact of technological change on jobs. Despite avoiding higher levels of unemployment experienced by many Western countries over the past 30 years, the rapid growth of information technology has increased the returns to investment in IT-embedded, capital goods and facilitated outsourcing and offshoring of work, which together have contributed to rising income inequality and little concern with the overall quality of jobs. Traditionally, industrial relations policies in Asia focused on minimizing conflict, often at the expense of workers' interests, however with some limited improvements in welfare policies (Deyo, 1989; 2012). Labour policies need to change in order to promote employment based on 'decent work' as defined by the ILO, and additional research should be undertaken on developing worker capabilities and affording opportunities for workers to participate in decisions that affect their work lives. This is particularly important, given the declining role of trade unionism in the Asia-Pacific region as indicated in Table 5.

Table 5: Trade union density in percent, selected Asia-Pacific countries, 2004 and 2016

	2004	2016
Australia	22.7	14.5
Japan	19.2	17.3
South Korea	10.3	10.1*
Singapore	20.1	21.2*
Malaysia	10.5	8.8

Source: ILO 2018
*Note: * refers to 2015, latest data available.*

Conclusions

This chapter has provided an overview of technological change and its consequences for employment patterns and work in selected Asia-Pacific countries against the background of Western experience. Our analysis shows that technological change has both positive and negative impacts, these varying with the type and scope of technological change, the context in which change occurs, and the power and interests of various social groups. Because the characteristics of future technology are uncertain, we cannot say whether the past is a reliable basis for anticipating the future. Indeed, this assumption may be problematic because for the first time in human history we face a massive extension of science-based innovation based on ever-increasing computing power and self-learning machines. Related to this, it is now possible for both emerging and advanced countries to undertake complex work, foreshadowing increasing global economic competition thereby adversely affecting employment security and the capacity of organisations and governments to plan future jobs. Based on past experience, we can however identify potential issues that necessitate on-going analysis as new technology is introduced. These are outlined below in the form of seven research imperatives.

First, there is the material, cultural and institutional contexts in which technology is introduced. Attention needs to be paid to changes in these contexts and their interrelationships. Particularly important are labour market institutions, which, as noted earlier, may limit opportunities for sharing the benefits of new technology and provide insufficient statutory support for mental and physical health, privacy, and education and training. Second, we noted how the demographic and labour force context plays a role, providing varying incentives for managers to introduce new technology. Third, there are contextual factors of a discontinuous kind, such as war, health pandemics, and climate change, all of which are on the policy horizon but difficult to predict accurately. A fourth aspect that requires study are the new business models that enable new technology to generate economic returns with far-reaching consequences. The growth of on-line retailing, particularly in China, is a good example where the effects on traffic flows and shopping malls is likely to be significant. A fifth dimension is the consequences of technological change for the occupational, sectoral and geographical distribution of jobs and hence for net employment. Recent studies predicting job destruction have varied widely while little attention has been paid to analysing and anticipating new occupations, including job quality, and their geographical location. These macro level outcomes will depend on a sixth factor: knowledge about decision-making processes in organisations, which includes assumptions about how new technology will be used. Understanding decision-making will impact managers and employees, including their relationships with one another and between them and new machines (e.g. robots and AI). Seventh and finally, it will be important to examine the anticipated consequences of technological change for social inequality and to canvass government policy options to promote new technology that has positive net social effects including protection of private data, while suggesting policies that limit or compensate for such negative effects as technological unemployment and creation of inferior quality jobs.

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CHAPTER 3

The Social Benefits of Automation and Facilitating Policies for Realizing Them - The Case of Japan in Aging Society

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The Social Benefits of Automation and Facilitating Policies for Realizing Them - The Case of Japan in Aging Society

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Introduction

In this article, “automated systems” refers to machines that bring about automation. Various functions can be automated. For example, automation is possible at all stages of sensing, analysis/judgment, and actuation. Automated systems can combine the automation of several particular functions related to sensing, analysis/judgment, and actuation. In addition, automated systems can be networked within the same field of use or across fields of use.

When considering the social benefits of automated systems, we must also assess the corresponding risks. Furthermore, consideration of the social benefits and risks of such systems must be extended to scenarios in predicted future societies.

For example, the Impact Assessment Sub-Committee of the Conference toward AI Network Society run by Japan’s Ministry of Internal Affairs and Communications has launched a field-by-field assessment of the use of artificial intelligence (AI) network systems. This assessment is

carried out based on an overall picture of a society to be realized in the near future due to the development of AI networks. Specific scenes of use (use cases) are established as the targets of assessment of social benefits and risks, and to identify which fields will use AI network systems in the future, these use cases are further sorted according to users' perspectives, based on the aforementioned picture of a future society (Conference toward AI Network Society, 2017). Each scenario is examined in two separate stages: a preliminary stage in which automation is introduced field by field, and a secondary stage addressing networks formed across fields. At each stage, the potential social benefits and risks that arise are analyzed. The focus of the analysis is on determining which stakeholders and categories of stakeholder will incur benefits and risks.

Below, scenarios, social benefits, and risks concerning automated systems in Japan are examined by drawing on studies produced for the aforementioned Conference toward AI Network Society and other entities under Japan's government. Although the fields of health, mobility, and public service are the main analytical focus of the Conference toward AI Network Society, the secondary stage of analysis uncovers connections with other fields. Next, I summarize findings regarding social benefits and risks across fields. As the AI systems addressed in the conference's report are more or less the same as the automated systems described in this article, I treat them as such below.

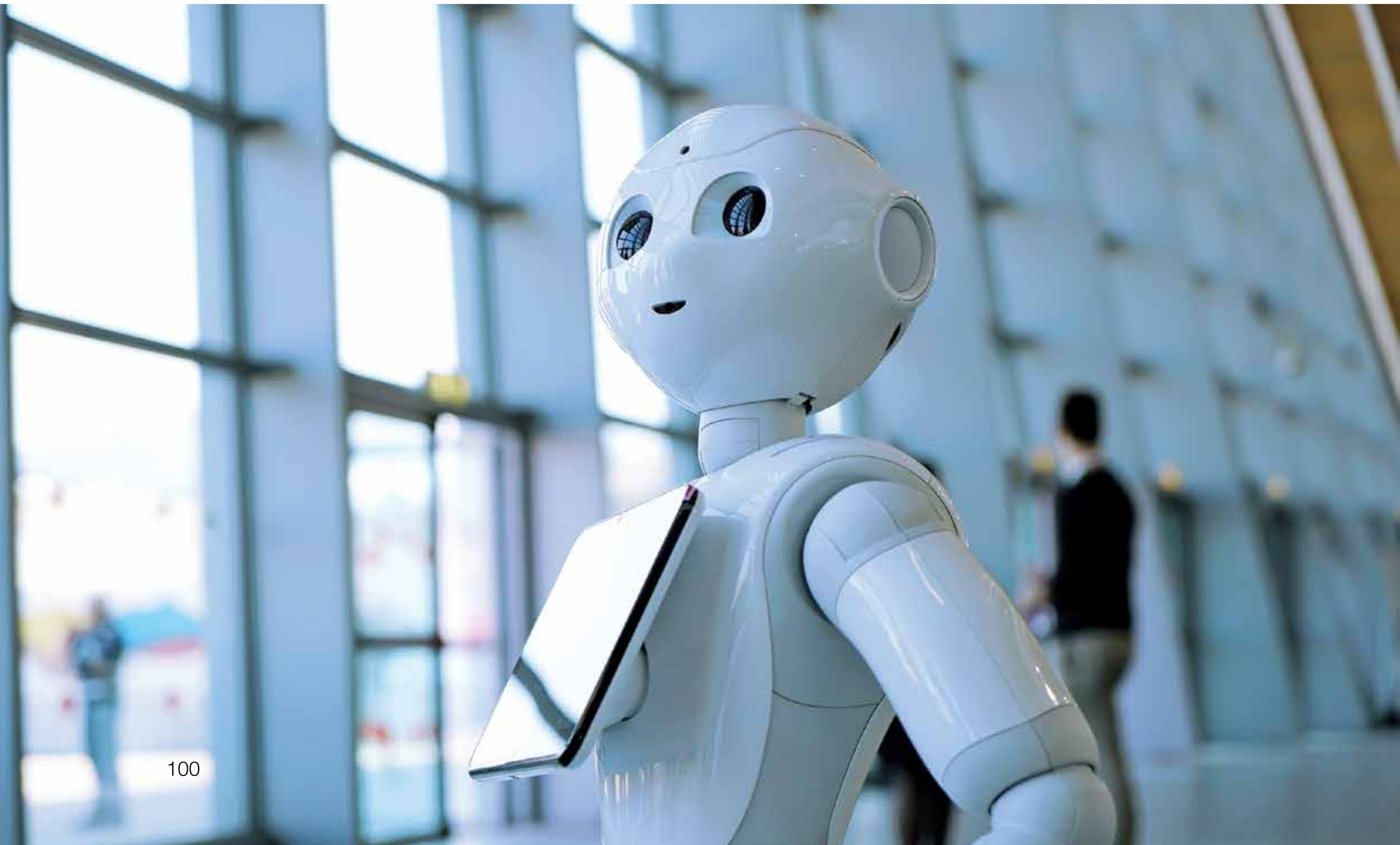
Following the above, I examine the facilitating policies implemented and required to realize the social benefits and minimize the risks of automated systems, taking into account the role of each stakeholder. Specifically, I focus on technology assessment to obtain a birds-eye view of the social benefits and risks incurred for each stakeholder. In addition, I focus on accident investigation systems as a necessary means of improving automated systems by learning appropriate lessons from accidents and incidents. Building such systems is essential to realize the social benefits associated with automated systems in every society.

Scenarios and Their Social Benefits and Risks

Overall Scenarios and Benefits in the Case of Japan

The same technology will have different social impacts if used in different social contexts. In Europe, for instance, where unemployment and immigration have become major social problems, automated systems are likely to reduce employment and have a negative impact on labor practices. In Japan, in contrast, due to an aging population and a declining birthrate, a labor shortage is becoming a major social problem; the labor saving afforded by automated systems may thus have a positive rather than a negative effect. Hence, depending on the national and regional context, the social impacts of a single technology may differ.

For example, the effects of automated systems on employment and labor are the focus of the documents “Automation and the Workforce” by the U.K.’s Parliamentary Office of Science and Technology (POST) (POST, 2016), “Working on the Robot Society” by the Rathenau Institute in the Netherlands (Rathenau Institute, 2015), and “The Future of Labour in the Digital Era” by the European Parliamentary Technology Assessment (EPTA, 2016). However, a broader focus is taken in “Preparing for the Future of Artificial Intelligence,” compiled by the National Science and Technology Council, for which the USA’s Office of Science and Technology Policy (OSTP) serves as secretariat. This report addresses the implications of AI in terms of transparency, accountability, ethical education, safeguarding, and the military (NSTC, 2016).



In Japan, in contrast, automated systems are generally assessed positively due to the country's aging population, declining birthrate, labor shortage, and potential for economic revitalization.

For example, the document "Growth Strategy 2017" recognizes that key to overcoming secular stagnation and achieving mid- and long-term growth is to realize "Society 5.0," which resolves various social challenges by incorporating the innovations of the rapidly progressing Fourth Industrial Revolution (e.g. the Internet of Things (IoT), big data, AI, robotics, and the sharing economy), into every industry and area of social life. The strategy document also notes that Japan was one of the first countries in the world to face social challenges such as a decline in productive-age population, the aging of local communities, and energy and environmental problems. The Fourth Industrial Revolution has created great potential demand for new things and services, which "may trigger unemployment issues," as they require fundamental improvements to productivity. As the Japanese labor force will continue to shrink in the long term, appropriate investment in human resources and changes to employment structure are needed to avoid the social frictions experienced in other developed countries (Council on Investment for the Future, 2017).

Similar arguments can be found in the "Report of the Committee on Artificial Intelligence and Human Society," published in 2017. The concluding remarks acknowledge that despite concerns about AI, "great benefits" can be obtained through its careful use. For example, although the birthrate in Japan is falling and Japanese society is aging, the use of AI can increase productivity by helping people to do work that they regard as creative and fun. Through the use of AI by people in various areas, including the elderly, work and other activities that were difficult in the past will be made easier, and "we can aim for a society where everyone can be active" (Committee on Artificial Intelligence and Human Society, 2017).

The "New Robot Strategy" approved by the Headquarters for Japan's Economic Revitalization in 2015 also recognizes that Japan faces the problems of a declining birthrate and an aging society, which are "progressing at an unparalleled speed worldwide," making Japan one of the first nations to encounter such challenges as a decline in the size of the working-age population, a labor shortage, and rising social security costs. The strategy treats these challenges as opportunities to promote the robotics industry. Accordingly, "society and institutions must undergo a transformation to take full advantage of robots," and "it is crucial to meet the requirements for a society where human[s] and robots can coexist and cooperate on a daily basis for the maximization of robot capacities." This kind of society is called a "robot barrier-free society." The strategy identifies key items of institutional/regulatory reform required to enable a robot barrier-free society, namely 1) deregulation and the establishment of a new legal system and environment enabling the effective use of robots; and 2) the establishment of relevant frameworks for consumer protection. An example of the latter is an information collection and cause investigation system designed to address serious product accidents/incidents caused by robots (Headquarters for Japan's Economic Revitalization, 2015).

Japan's Ministry of Internal Affairs and Communications (MIC) has set up the Conference toward AI Network Society and published reports offering detailed and comprehensive coverage of related benefits and risks (Conference toward AI Network Society, 2017; 2018). The following sections introduce the more detailed impacts identified in the report in relation to health, mobility, and public service scenarios. Scenarios are differentiated by stage: categorized as either preliminary stage scenarios (AI networking within a specific field) or secondary stage scenarios (AI networking across fields). Health, mobility, and public services are the key fields in which the elderly and other members of society can gain benefits through the use of automated systems.

Health Scenario (Conference toward AI Network Society, 2017)

Preliminary Stage Scenario on Health (Networking within the Field)

Compared with the independent operation of automated systems, networks of automated systems will offer people better access to health management and nursing services that respond to their health status and any changes in that status, such as the following: recipe suggestions based on their day-to-day health and the food they have in storage; fast transportation to hospitals and care facilities provided by self-driving vehicles, based on changes in individuals' health status; and suggestions for appropriate care plans and support from robot care providers.

- **Predicted uses in this Scenario**
  - Suggestions for recipes that are appropriate to individuals' health status, medical history, and day-to-day health status and can be made with food already stored in the refrigerator or freezer.
  - Transportation by self-driving car to hospitals or care facilities in response to changes in health, identified through information from wearable devices or visual information sent by cameras.
  - Suggestions for optimal care plans based on individuals' care history and health status, and the provision of support by care robots.

Secondary Stage Scenario on Health (Networking across Fields)

Forming networks between automated systems across fields such as medicine/care, agriculture, retail, daily support, public service, and finance/insurance will allow robots to automatically order and cook food. This will also enable public services and financial/insurance-related services to be provided in accordance with users' needs, improving the service level of health management and care.

- **Predicted uses in this Scenario**
  - (Medicine/care + agriculture + retail + daily support)

    In addition to suggesting health-enhancing recipes in accordance with users' health status, medical history, and daily changes in health, such networks can facilitate automatic ordering from agricultural producers and retailers based on the food users have in storage, allowing cooking robots to prepare meals based on these recipes. The consumer will receive not only recommendations for food items but also real-time information on production and distribution during the delivery process.

  - (Medicine/care + public services + finance/insurance)

    To support users in making applications or applying for renewals, information on related public services (support services such as grants and subsidies, medical check-up services, and community activities) will be provided in accordance with information about the users' health (such as their medical history and care history). Based on this information, financial/insurance-related services can also be customized to meet individual needs.

Social Benefits of Health Scenario

- **Social Benefits at Preliminary Stage (Networking within the Field)**
  - Income opportunities will increase (for consumer electronics manufacturers and others). This will support disease prevention and health management (for citizens).
  - Income opportunities will increase (for care service providers and car manufacturers). The cost/burden of transport to hospitals and other facilities will be eased (for citizens).
  - Care services can be tailored to individuals, including the elderly, in accordance with their health status. The care business will thus become more efficient (for care providers and others). Higher-quality care services will be available. Having a robot to talk to will ease or eliminate people's (citizens') loneliness.

- **Social Benefits at Secondary Stage (Networking across Fields)**
  - In addition to being able to eat safe food with peace of mind, people, including the elderly, will benefit from the prevention of disease and the appropriate management of health. Eliminating the tasks of shopping and cooking will free up more time to spend on other things, such as hobbies (for citizens). Income opportunities will increase (for consumer electronics manufacturers, robot manufacturers, agricultural producers, and retailers).
  - People will receive various public services without needing to seek them out. The burden of following complex procedures will thus be eased. Public services and financial services will be tailored to each citizen. The work of local governments, financial institutions and so on will be more efficient.

Risks of Health Scenario

- **Risks at Preliminary Stage (Networking within the Field)**
  - Suggested recipes may be inappropriate to individuals' health status, due to insufficient knowledge or false or biased data. If image recognition is not accurate enough, food items may be mistaken for each other (by developers and providers). Sensitive information related to individuals' health (medical history, health status and so on) may be leaked or misused due to abuses such as hacking (creating problems for consumer electronics manufacturers and other agents).
  - If image recognition is not accurate enough, sudden changes in a person's health may be overlooked (a risk incurred by developers and providers). Due to malfunction or mismanagement, self-driving vehicles may become out of control or dysfunctional. Visual images obtained from cameras (personal information) may be sold to or shared with third parties without individuals' consent (problematic for care service providers, car manufacturers, and so on).
  - Sensitive information related to individuals' health (medical history, health status, and so on) may be leaked or used inappropriately due to abuses such as hacking (incurring problems for developers and providers). If automated systems are insufficiently coordinated, it may be impossible to propose optimal care plans or provide optimal support. Visual images from cameras (personal information) may be sold to or shared with third parties without individuals' consent (problematic for care providers and others).

- **Risks at Secondary Stage (Networking across Fields)**
  - If automated systems are insufficiently coordinated, users may not be able to follow the recipes provided. Production/distribution data may be tampered with through abuses such as hacking (which is problematic for consumer electronics manufacturers, robot manufacturers, agricultural producers, and retailers).
  - Sensitive information related to individuals' health (medical history, health status, and so on) may be leaked and used inappropriately due to abuses such as hacking (creating problems for local governments, financial institutions, and so on).

Mobility Scenario (Conference Toward AI Network Society, 2018)

Preliminary Stage Scenario on Mobility (Networking within the Field)

Compared with the independent operation of automated systems, networks formed between automated systems will allow people, including the elderly, to enjoy a more pleasant transport experience due to the deployment of self-driving cars, the full automation of buses and taxis, traffic light systems responsive to the flow and volume of traffic, the auto-adjustment of traffic jam prediction and recommendations for routes to avoid, suggestions for sight-seeing routes, and real-time adjustments that take into account event information and the weather.

- **Predicted uses in the scenario**
  - Self-driving vehicles and fully automated buses and taxis.
  - Real-time auto-adjustment of traffic light systems, traffic jam prediction, recommendations for routes to avoid in response to the volume and flow of traffic, and adjustments to taxi allocation and bus operation routes that take into account event information and the weather.
  - Suggestions for sight-seeing trips in line with one's tastes and preferences, including recommended sight-seeing points, with real-time adjustments to routes based on congestion at sight-seeing points or on sight-seeing routes, how trains are running, and the weather.

Secondary Stage Scenario on Mobility (Networking across Fields)

When networks are formed between automated systems across fields, such as medicine/care, agriculture, retail, daily support, public services, and finance/insurance, mobility will play a more important role across fields, taking the following forms: transport/chauffeuring to hospital or care facilities by self-driving vehicles; identifying specialists at hospitals based on availability at times of emergency; and the transport and sales of goods by self-driving vehicles.

- **Predicted uses in the scenario**
  - (Mobility + medicine/care + distribution + retail)
    In addition to providing transportation to hospitals or care facilities by self-driving vehicles, the system will match users with medical specialists in accordance with hospitals' availability to receive patients (available beds and so on) at times of emergency, and provide real-time adjustment to ensure that the best possible routes are taken. In addition, self-driving vehicles will transport goods (long haul) and carry out mobile sales.
  - (Mobility + education + work + medicine/care + distribution + retail + other fields)
    People can follow an educational curriculum at home using robots, virtual reality, or augmented reality; work from home using the Internet; receive diagnoses through remote medical care when they are ill or injured; shop with automated ordering and delivery; and receive care from care robots. This will allow people to live their lives to the full even if they are not mobile.

Social Benefits of Mobility Scenario

- **Social Benefits at Preliminary Stage (Networking within the Field)**
  - Traveling by car will become easy for everyone, including the elderly and the disabled. The number of traffic accidents will decrease. The problem of a shortage of bus drivers in the countryside will be solved, and transport networks such as scheduled bus services will be maintained (benefiting citizens). People will be able to make better use of their time while traveling by car. The labor costs associated with driving buses and taxis will be reduced (for citizens and service providers).
  - Traffic management systems will be upgraded. As such systems will provide highly accurate information in real time, traffic information providers will have more opportunities to generate revenue. The demand and supply of buses and taxis will be better matched, providing further opportunities to generate revenue (for the police and business operators). People will enjoy a more pleasant transport experience, as initiatives undertaken to eliminate or reduce traffic jams will reduce traveling and waiting time. The environmental load (carbon dioxide emissions) will be lessened (for citizens).
  - As traveling will be better matched with individuals' hobbies and preferences, it will become more enjoyable. People will be able to travel in comfort, avoiding traffic jams and swiftly changing trains. Visitor prediction will be more precise, and management will be more flexible and efficient (benefiting citizens, tourism operators, and caterers).

Social Benefits at Secondary Stage (Networking across Fields)

- As emergency transport will take less time, survival rates will improve. The labor costs associated with distribution will be reduced (for fire fighters, medical institutions, care providers, and distributors). Those who find the use of public transport difficult and who cannot drive will be better able to access hospitals or care facilities. People will be able to purchase goods from their homes or near their home (benefiting citizens).
- Reducing traveling time will allow people to make better use of their time. Travel-related congestion will be eliminated from society. Increased opportunities will be available to generate income related to goods/services in various areas and fields (for citizens and service providers).

Risks of Mobility Scenario

- **Risks at Preliminary Stage (Networking within the Field)**
  - Automated systems may malfunction due to abuses such as hacking and improper use, which may lead to accidents. It may be impossible to identify where responsibility lies if the decisions made by an automated system when an accident happens cannot subsequently be examined (problematic for developers and providers). If automated systems are insufficiently coordinated, accidents may occur, operation may not be smooth, and it may be impossible to provide appropriate traffic jam prediction services or to adjust routes to avoid congestion (incurring risks for the police, citizens, and business operators).
  - Personal data (about hobbies and preferences) may be leaked, and inappropriately used due to abuses such as hacking (problematic for developers and providers). If automated systems are insufficiently coordinated, it may be impossible to make appropriate suggestions for or adjustments to transport routes. Personal data (on hobbies/preferences) may be sold to or shared with third parties without individuals' consent (problematic for citizens, tourism operators, and caterers).

- **Risks at Secondary Stage (Networking across Fields)**
  - Users may be matched with inappropriate specialists, and it may be impossible to optimize routes through adjustment due to insufficient coordination between automated systems (problematic for fire fighters, medical institutions, care providers, and distributors).
  - Personal data (academic grades, health status, etc.) may be leaked or inappropriately used due to abuses such as hacking (problematic for developers and providers). People may be unable to receive appropriate services due to insufficient coordination between automated systems. Communication skills may deteriorate (or not develop at all) if relationships with other human beings are weakened. As people become more dependent on automated systems, human dignity and autonomy may be undermined (for citizens and service providers).

Public Services Scenario (Conference toward AI Network Society, 2018)

Preliminary Stage Scenario on Public Services (Networking within the Field)

Compared with the independent operation of automated systems, reciprocal networks of automated systems will provide better public service functions and allow various challenges to be addressed more quickly, such as the following: reviewing documents related to grants and subsidies and deciding whether to grant benefits; using social media to identify problems and suggest solutions; and drafting financial and monetary policies based on advanced simulations.

- **Predicted uses in the scenario**
  - When applications for grants and subsidies are made, automated systems can be used to check whether application forms are complete and to decide whether to award grants by automatically verifying the eligibility of applications by comparing forms against the necessary information.
  - Information will be collected from citizens through services such as social media to identify challenges that the government should tackle and suggest appropriate responses, taking into consideration the experiences of other local governments with similar problems.
  - Statistical information (such as data on population, birthrate, and unemployment rate) and data on economic indices (such as gross domestic product, stock price, and consumer price) will be collected to carry out various simulations and propose policies related to government spending, finance, and social security.

Secondary Stage Scenario on Public Services (Networking across Fields)

When networks are formed between automated systems across fields, such as governments, smart cities, housing, and work, individuals' eligibility to receive benefits such as pensions can be evaluated based on information on their daily lives and automated patrolling. Job matching based on profiling will also be offered, and people will be able to live safer, richer, and more secure lives due to the transboundary coordination of governmental functions.

- **Predicted uses in the scenario**
  - **(Public services + smart cities + housing)**
    Individuals' eligibility to receive various benefits, such as pensions or child benefits (existence checking), will be checked using information provided by smart meters on whether people are present (such as information on the daily use of electricity and water) and automated patrolling or care services.
  - **(Public services + rich life)**
    Jobs and occupations will be suggested based on profiling to suit applicants' abilities and aptitudes (job matching).

Social Benefits of Public Services Scenario

- **Social Benefits at Preliminary Stage (Networking within the Field)**
  - Automated systems will provide benefits in terms of labor saving and the optimization of administrative management (for government organizations). The period between application and decision making and the waiting time incurred by information processing and decision making will be reduced (for citizens).
  - Problems that would previously have gone unnoticed may now be recognized. These problems will now be handled appropriately with reference to similar prior examples (for local governments). Problems that require resolution will be forwarded for administration by citizens and connected with solutions. A sense of participation in the administration will be heightened (for citizens).
  - Many kinds of policy, such as public finance management and monetary policies, will be more quickly, appropriately, and efficiently implemented. Problem solving (by government organizations) will be approached from points of view that would previously have gone unacknowledged. The burden on citizens, such as tax and social security contribution, will be reduced.

- **Social Benefits at Secondary Stage (Networking across Fields)**
  - All kinds of compensation, such as pensions and childcare allowances, will now be protected from fraud (for government organizations). Citizens will live more safely and with greater peace of mind.
  - With an increase in the workforce, tax yield will increase, and expenditure on unemployment allowances will be reduced (for government organizations). Modes of work suiting people's abilities and aptitudes will become available (for citizens).

Risks of Public Services Scenario

- **Risks at Preliminary Stage (Networking within the Field)**
  - Defects in, for example, written applications may be overlooked if character recognition is not sufficiently accurate. Personal data recorded in written applications may be leaked or misused due to abuses such as hacking (which is problematic for developers and providers). If automated systems are insufficiently connected, it may be impossible to obtain the necessary information, and incorrect conclusions may be reached regarding proper payments (creating problems for government organizations).
  - It may be impossible for developers and providers to construct appropriate learning models if the number of previous examples does not increase, or to propose appropriate policies if information is insufficient or biased. Government organizations may make incorrect responses to proposals grounded on false information if the veracity of the information gathered cannot be discerned.
  - It may be impossible for developers and providers to make appropriate proposals due to insufficient knowledge or false or biased data. Automated systems may be inadequately coordinated, fail to obtain sufficient information, and/or carry out erroneous simulations, preventing administrative bodies from proposing appropriate policies.

- **Risks at Secondary Stage (Networking across Fields)**
  - The images used by services such as security or lifestyle information services (including information on the existence or non-existence of residents) may be leaked or misused due to hacking, for example (creating problems for developers and providers). If consent to use data such as lifestyle information cannot be obtained, it may be impossible to confirm that individuals qualify to receive benefits. Automated systems in smart meters and automated patrol cars may be inadequately coordinated, and insufficient patrols may be available to surveil absentee homes, which may then result in multiple patrol vehicles rushing to the same place (problematic for government organizations).
  - Sensitive information (profiling results and data on educational history, annual income, etc.) may be leaked or misused due to hacking or other abuses. Profiling data may be insufficiently detailed, resulting in inappropriate matching, as a result of insufficient knowledge or false or biased data (problematic for developers and providers). Sensitive data (profiling results and data on educational history, annual income, etc.) may be sold to or shared with third parties without individuals' consent (problematic for government organizations).

Cross-Cutting Analysis

Although concrete benefits and risks often differ between fields, several issues arise across fields. Three cross-cutting issues are discussed below.

Social Benefits

Scenario analysis to date has identified three categories of social benefits of automated systems: increasing effectiveness, increasing efficiency, and providing new services.

- **Increasing Effectiveness**
  When automated systems increase effectiveness, they increase the quality or availability of services. In the field of healthcare, care services can be tailored to individuals in accordance with their health status. In terms of mobility, traveling by car will become easy for everyone, including the elderly and the disabled. In addition, the number of traffic accidents will decline and the environmental load (carbon dioxide emissions) will be lessened. As emergency transport will thus take less time, survival rates will improve. Those who find the use of public transport difficult and who cannot drive will be better able to access hospitals or care facilities. In the field of public services, many kinds of policy, such as public finance management and monetary policies, will be more quickly, efficiently, and appropriately implemented. In addition, all kinds of compensation, such as pensions and childcare allowances, will be protected from fraud.

- **Increasing Efficiency**
  When automated systems increase efficiency, they reduce the cost of services and enable unused resources to be utilized for other purposes. The healthcare business will become more efficient, and the burden of following complex procedures will be eased. In terms of mobility, people will make better use of their time while traveling by car, and the labor costs associated with driving buses and taxis will be reduced. In the field of public services, labor will be saved and administrative management will be optimized. The period between applications and decisions and the waiting time incurred by information processing and decision making will be reduced.

- **Providing New Services**
  Automated systems have the potential to provide services that were not previously available. In the field of healthcare, high-quality care services will be available. For example, having a robot to talk to will ease or eliminate the loneliness of elderly and other citizens. In terms of mobility, people will be able to purchase goods from home. In the field of public services, problems that would previously have gone unnoticed may now be recognized. Such problems will be more appropriately handled with reference to similar prior examples.

Effects on Employment and Work Styles

The employment of bus and taxi drivers (mobility field), and certain other types of profession, such as desk jobs (public service field) will decrease. A decreasing demand for employment will not be problematic in some sectors, especially given Japan's aging society and shrinking population. Meanwhile, the jobs available at appliance and robot manufacturing companies will increase, and employment connected with new tasks such as the tuning of learning data and parameters and information security (various fields) will increase. In addition, personnel will be more easily reshuffled; for example, client-facing desk jobs can be replaced with jobs in areas such as policy/ decision making (public services and healthcare).

Generally, routine work will decrease, and non-routine and innovative work may increase. Therefore, appropriate education and social policies will be essential to enable Japan's workforce to transition to the newly needed roles.

Implications for Social Values

A question that must be answered is whether to permit the use of automated systems for enhancement. Similar questions have been asked in the field of nanotechnology and in discussion of implanting devices in humans. Although glasses and hearing aids are devices for enhancement, hardly anyone would say that their use is inappropriate. However, controversy arises when proposals are made for implanting devices based on nanotechnology and AI into the body. In addition, the question of which kinds of enhancement are permissible and which are not has different answers depending on the specific context or an individual's situation in life. Responses also differ between everyday life and sports. In the sphere of sports, the issue of doping is controversial, as standards for fairness are strict and rigorous. Conversely, in everyday life, enhancement using AI or other machines may be socially desirable.

We also face the problem of how life is viewed. One view holds that individuals are ideally free of the obligation of work, whereas another holds that work is essential to a good life, because it provides self-fulfillment. Perceptions on this point vary depending on the occupations or tasks to be replaced by automated systems. Significant support may be available for the automation of dangerous occupations and tasks.

In addition, the issue arises of what kind of ethical status to give to automated agents, such as robots, that interact meaningfully with humans. The question of whether to give an equivalent ethical status to animals will also become a problem. The ethical status of animals is already controversial in the context of animal welfare and animal rights. Moreover, as automated systems share and analyze information on individuals' trends and tastes, the problem emerges of undermining individual thought processes, which are the basis for autonomous decision making.

Distributional Implications of Social Impacts

It is important to be cautious when assessing the distributional implications of these social impacts. It is generally necessary to clarify and balance the various risks and benefits of these impacts during decision making and policy making. Ultimately, however, different risks and benefits are incurred by each stakeholder. Individual responses and actions naturally reflect the risks and benefits incurred by an individual. For example, the effects of automated systems on employment naturally differ depending on the occupations and tasks performed by individuals. Ultimately, when decision making and policy making are based on social impacts, one cannot avoid making political judgments that involve trade-offs, whose benefits or risks should be considered, depending on the situation.

Possibility of Malfunction and Need for Learning

Automated systems may malfunction due to defects in automated systems or the inappropriate coordination of automated systems based on false or biased data. In the field of healthcare, it may be impossible to suggest recipes that are appropriate to individuals' health status due to insufficient knowledge or false or biased data, and if image recognition is insufficiently accurate, food items may be mistaken for each other. In the field of mobility, automated systems may malfunction due to abuses such as hacking and improper use, which may lead to accidents. If automated systems are insufficiently coordinated, accidents may occur, operation may not be smooth, and it may be impossible to provide appropriate traffic jam predictions or adjust routes to avoid congestion. In the field of public services, it may be impossible to construct an appropriate learning model if the number of previous examples does not increase, or to propose appropriate policies if information is insufficient or biased.

It may also be difficult to identify root causes if the decisions made by an automated system when an accident happens cannot be examined. Therefore, it is important to establish a mechanism for learning to identify the root causes of malfunction and feed back the lessons learned to the design of automated systems.

Facilitating Policies to Realize Social Benefits

In the previous Section on Scenarios and their Social Benefits and Risks, scenarios, social benefits, and risks are examined by drawing on studies by various government entities and research produced for the aforementioned Conference toward AI Network Society in Japan. The analysis of the Conference toward AI Network Society focuses on the fields of health, mobility, and public services, but connections with other fields are also examined in the second stage, with attention to networks formed across fields.

Three main categories of social benefits are identified: increasing effectiveness, increasing efficiency, and providing new services. However, concrete social benefits and risks differ depending on the fields and social contexts in which automation systems are embedded. The cross-field analysis also reveals common issues to be dealt with in each society, namely effects on employment and work styles, implications for social values, and the distributional implications of social impacts. In addition, addressing the possibility of malfunction of automated systems and developing a mechanism for learning are identified as common agendas.

Following the above, I examine the kinds of facilitating policies necessary to realize these social benefits and minimize risks, taking into account of the role of each stakeholder. Compared with the relatively direct policy interventions undertaken in China and Korea, more indirect and softer policy tools are used by the Japanese government. First, I focus on technology assessment as a way of obtaining a birds-eye view of the social benefits and risks incurred by each stakeholder. Technology assessment is vital in every society to realize the benefits and risks of automated systems and take necessary steps to deal with their impacts on employment and work styles, their implications for social values, and the distributional implications of their social impacts. Second, I focus on the accident investigation systems required to improve automated systems by learning appropriate lessons from malfunction; that is, accident and incident investigation systems. Building these kinds of systems is essential if every society is to realize the social benefits associated with automated systems.

Technology Assessment as a Tool for Facilitating Transition

The Role of Technology Assessment

Decision making related to research on and the development and use of technology must be based on a clear sense of the various social impacts and society's diverse expectations of such technology. In addition, advice must be gained from a comprehensive series of scientific and technological insights and innovations (Tran and Daim, 2008). In terms of social impacts, it is important to visualize not only risks but also benefits. Clarifying the social impacts of technology is fundamental to decision making on technology, or in other words the implementation of politics related to technology (Shiroyama, 2011).

From this perspective, technology assessment is a mechanism for clarifying the social impacts of technology. Technology assessment can be defined as an activity that broadly examines and analyzes the impacts of technological developments on society from an independent standpoint, communicates these impacts to the public, politicians, administrations, corporations, or researchers and developers, and supports mutual discussion, decision making, and policy making. More specifically, technology assessment can play a role in the following activities: 1. Organizing the known and unknown aspects of technology and its social impacts; 2. Clarifying the social and political issues that arise from scientific and technological developments; 3. Visualizing various perceptions of and value judgments on science and technology and society; 4. Encouraging mutual understanding, cooperation, and knowledge exchange among stakeholders; 5. Assisting in innovation and the design of new systems; 6. Deepening communication with a broad range of individuals and the public (Shiroyama et al., 2011; Shiroyama, 2018, Chapter 9).

A technology assessment can focus on a number of social impacts that are diverse and broad. Risk assessment and ELSI evaluation can be considered components of a technology assessment. An important point to note when implementing a technology assessment is that the same technology will have different social impacts if used in different social contexts.

Options for Technology Assessment Frameworks

A technology assessment is not a direct policy intervention and does not constitute decision making or policy making per se; it is a supportive activity that forms the basis for decision making and policy making. Therefore, maintaining a certain "appropriate distance" between the technology assessment organization or activity and decision making and policy making on science and technology enables wide-ranging discussion, and can also contribute to decision making and policy strategy making. If this distance is too long, the results of the technology assessment will not be incorporated into the decision making or policy making, but too short a distance will impede the wide-ranging and flexible discussion required for an effective technology assessment (Shiroyama, 2018, Chapter 9).

Such frameworks and systems are not uniform, and some aspects must be designed based on the characteristics of the individual context. For example, it is more important to embed technology assessment from the bottom up in fields that utilize highly decentralized information technology such as automated systems, than in fields involving centrally systematized technologies such as atomic energy or outer space exploration technology.

Below, in relation to the kinds of framework possible when implementing a technology assessment of an automated system, I refer to trials of technology assessment of automated systems around the world, focusing on existing and possible practices in Japan.

- **Technology Assessments Undertaken on the Initiative of Individual R&D Institutions**
  Individual public and private R&D institutions use some of their R&D funding to conduct technology assessments of their own R&D, and may directly incorporate the results into their R&D, unmediated by government policy making (Shiroyama et al., 2010). Constructive technology assessments and real-time technology assessments can be categorized among these kinds of attempts (Schot and Rips, 1997; Guston and Sarewitz, 2002).

  In April 2016, at the Riken Institute of Physical and Chemical Research in Japan, the Center for the Advanced Intelligence Project (AIP Center) was established to implement the "Integrated Project in Artificial Intelligence, Big Data, IoT (Internet of Things) and Cybersecurity." Within the AIP Center, a group responsible for studying AI in society examines the social image of AI and its impact on concepts such as humanity and the instrumentality of technology, and researches the implementation of AI in society, technological solutions to the issues arising from AI, and the facilitation of communication between AI and humans. When conducting decentralized R&D, as in the case of information technology, it seems particularly important to implement mechanisms like this, which provide direct feedback on the R&D process without the mediation of government policy making.

  However, in the case of this kind of voluntary technology assessment, which is conducted by a R&D institution, the challenge arises of how to ensure a certain level of independence to secure a broad perspective that accommodates a public purpose. Relying solely on project funds from individual R&D institutions narrows perspectives, demands short-term and direct results, and runs the risk of being unable to adequately address the needs of society. Therefore, when technology assessments are conducted by R&D institutions, it is necessary to ensure participation not only from experts in the chosen R&D field at the R&D institution in question, but also from experts with a wide range of perspectives from a broad range of fields.

- **Funding Frameworks for Technology Assessment Activities Established by the Government**
  Another mechanism exists for securing funding for technology assessment activities within the government to ensure a diversity of perspectives; the specifics of implementation are delegated to organizations outside the government. As under the U.S.A.'s 21st Century Technology Research and Development Law, a certain proportion of R&D funding is provided to defray the costs for research on ELSI (Shiroyama et al., 2010).

The institutions implementing this kind of technology assessment include universities, research institutes, and NPOs. In Japan, in relation to new information technology, the Human-Information Technology Ecosystem program was established in 2016 within the Research Institute of Science and Technology for Society of the Japan Science and Technology Agency, the agency facilitating R&D under the Ministry of Education, Culture, Sports, Science, and Technology. This program deals with issues that arise when introducing new information and technology, such as AI, to society, and constructs venues and platforms that allow information on these issues to be fed directly back to the R&D sites to promote the coevolution of technology and society. The existence of a number of institutions implementing technology assessments is beneficial in presenting broader perspectives to society through diverse channels and in firmly establishing technology assessment as a social activity.

- **Frameworks for and Systems of Technology Assessment at the National Government Level**

Next, technology assessments can be conducted at the national government level. When technology assessments are conducted by a national organization, the agency is situated within the national parliament/congress or administrative organization. If situated within an administrative organization, the agency may take various forms depending on the kind of department in which it is situated, whether a cabinet secretariat, cabinet office, ministry, or related institution (Shiroyama et al., 2010).

In the U.S.A., the Office of Technology Assessment (OTA) was founded in 1972, and operated until 1995. In the U.K., POST was set up in 1989 as an experimental organization, and following its trial activities, was formally approved in 1993 on a time-limited basis; it was permanently installed in 2001. In the Netherlands, the Netherlands Office for Technology Assessment was set up in 1986 within the Royal Netherlands Academy of Arts and Sciences as a compromise between the Ministry of Education, Culture, and Science and the States General. The office was renamed the Rathenau Institute in 1994, and became a venue for stimulating public discussion on technology (Shiroyama et al., 2011). Several other government-centered technology assessments have been implemented. For example, the OSTP was set up in the U.S.A. in 1976 within the Executive Office. Subsequently, in October 2016, the National Science and Technology Council, for which the OSTP serves as a secretariat, published a report entitled “Preparing for the Future of Artificial Intelligence” (NSTC, 2016).

Trials have also been implemented in Japan to institutionalize technology assessment, centered on the National Diet. For example, the Committee on Science, Technology and Policy, set up in June 1994 with bipartisan participation from Diet members and academic experts, attempted, albeit unsuccessfully, to submit a bill to the Diet to establish a Science and Technology Evaluation Council (Shiroyama et al., 2010). Within the government, bodies such as the former Science and Technology Agency have considered implementing technology assessment for many years. In a recommendation submitted in April 1971, the Science and Technology Council posited that “technology assessments must be introduced at every opportunity to implement policy, such as in drafting plans, implementing and evaluating R&D, and applying research results to society and the economy." Under the Technology Assessment Comprehensive Review Committee set up in April 1971, the Science and Technology Agency Planning Bureau has conducted case studies of agrichemicals, high-rise buildings, and computer-assisted instruction (CAI) (Shiroyama, 2010; Shiroyama et al., 2010). The need for technology assessment has also been repeatedly indicated in the Basic Plans for Science and Technology. In Chapter 5 of the 2011 4th Basic Plan for Science and Technology, entitled "The Development of Policy Created with Society", "Section 2, Deepening the Relationship between Society and Scientific and Technological Innovation (1) Promoting Scientific and Technological Innovation Policies based on a Public Perspective and (2) Responding to Ethical, Legal and Social Issues," it is posited that "the state, in addition to considering the institutional set up of technology assessment… when making policy decisions, will share the results of technology assessments with the public and will push forward approaches to establish [a] wide-ranging consensus." Similarly, in the 5th Basic Plan for Science and Technology of 2016, Chapter 6, entitled "Deepening the Relationship between Scientific and Technological Innovation and Society", "(4) Approaches to Ethical, Legal and Social Issues" states that "in relation to the implementation in society of science and technology, as seen with genetic diagnosis, regenerative medicine and AI for example, cases are increasing, which require decision making as a society in relation to the ethical and legal issues… from the perspective of promoting the use of science and technology in society… we will promote technology assessments that multilaterally and comprehensively examine the effects of science and technology."

Having general trends in technology assessment, such as those mentioned above, as a background, technology assessments of AI have also been conducted experimentally in Japan recently. First, in relation to the Diet, as part of a survey of science and technology, a survey of perspectives on AI and robots in connection with labor and employment was conducted in 2017 by the Diet Library (Diet Library, 2018).

Within the government, the Council for Science, Technology and Innovation, for which the cabinet office serves as a secretariat, set up a Committee on Artificial Intelligence and Human Society in May 2016 and compiled a report in March 2017. Based on discussion of the ELSI relating to AI both within Japan and at an international level, this committee report specifically considered ethical, legal, economic, educational, social, and R&D-related points of contention with the objective of "focusing on artificial intelligence technology that already exists and that is highly likely to be realized in the near future, as well as on the society that propagates and disseminates that technology," and clarifying the expected benefits, considerations, and future issues to be addressed and directions for addressing them. In doing so, the committee addressed a number of cases related to the four "representative fields" of mobility, manufacturing, services for individuals, and dialogue/exchange, and sought to clarify the points of contention from the viewpoints of various stakeholders, such as corporations, the government, people from different generations, users, researchers and developers, leaders in culture and the arts, and children (Committee on Artificial Intelligence and Human Society, 2017).

From the specific perspectives of ministries and agencies, assessments have progressed to the social impacts of automated systems and how to deal with them. Within the Ministry of Economy, Trade, and Industry (METI), coinciding with the Fourth Industrial Revolution and based on the possibility of rapid changes to the country's industrial structure, a group entitled Cross-Sectional Systems Study Group toward the Fourth Industrial Revolution was established to investigate responses to the current situation and issues related to cross-sectional systems, such as competition policies and intellectual property policies. An investigation was conducted from January to July 2016, and a report was compiled accordingly (Cross-Sectional Systems Study Group toward the Fourth Industrial Revolution, 2016). Similarly, within the Ministry of Health, Labor, and Welfare (MHLW), the Committee on the Utilization of AI in Healthcare was established to investigate areas of healthcare in which AI is required, the foundational architecture required to utilize AI, and the efficacy and safety of AI, and a report on the findings was compiled in June 2017 (Committee on the Utilization of AI in Healthcare, 2017). Rather than simply clarifying the social impact of autonomous cars, to ensure their competitive strength and specifically investigate approaches taken by governments, industry, and academia to resolve social issues such as traffic accidents, the Autonomous Car Business Investigative Commission was jointly established by the METI and the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in February 2015. In March 2016, a report on the findings entitled "Policy in the Lead Up to the Realization of Autonomous Cars" was compiled (Autonomous Car Business Investigative Commission, 2016).

Technology assessments organized by either ministries and agencies or R&D institutions, such as those mentioned above, were conducted at organizations close to the sites of actual use of automated systems or close to the sites of R&D. In contrast, comprehensive technology assessments at a certain distance from the site of actual usage or R&D have been implemented since 2015 by the Institute for Information and Communications Policy under the Ministry of Internal Affairs and Communications (MIC). The results of the institute's assessments are explained in Section on Scenarios and their Social Benefits and Risks (Conference toward AI Network Society, 2017; 2018). The MIC's Institute for Information and Communications Policy set up a study group in January 2015 on the future image of information and communications technology (ICT) toward which intelligentization is accelerating. Based on the group's proposals, the Institute aimed to investigate an aspirational image of society and its basic philosophy in relation to ICT intelligentization as well as to conduct impact and risk studies and organize immediate issues; it established an ICT Intelligentization Impact Assessment Committee (its name was subsequently changed to the AI Networking Investigative Committee). The AI Networking Investigative Committee was composed of experts from various fields. The AI Networking Investigative Committee proposed the Wisdom Network Society as an image of an aspirational human-centered society to be achieved through the development of AI networking, and published a report providing a fundamental evaluation of the impacts and risks that AI networking brings to society and the economy. Based on the above, with the participation of industrial stakeholders, in addition to experts in science and engineering, the humanities, and social science, the Conference toward AI Network Society was established in October 2016, as a successor to the AI Networking Investigative Committee, to investigate the social, ethical, and legal issues involved in promoting AI networking. The Subcommittee for Development Principles and the Subcommittee for Impact Assessment were established under this Conference. The focus of the technology assessments conducted by the AI Networking Investigative Committee and Conference toward AI Network Society was panoramic and comprehensive. And, compared with a number of other technology assessment activities in Japan, they took a certain distance from decision making and policy making on the ground. Hence, to a certain extent, free and open discussion was guaranteed. However, the issue arises of how to link (or not to link) the impact and risk assessment activities of the Conference toward AI Network Society with the policy making and decision making activities of various ministries and R&D institutions.

- **Conducting International Technology Assessments**

In fields in which the rapid advancement of technology is expected globally and simultaneously, diverse stakeholders in the international arena are likely to take the initiative in establishing a venue for technology assessments at an international level. For example, in relation to nanotechnology, organizations such as the International Council on Nanotechnology have engaged in activities based at universities (Shiroyama et al., 2010).

Trials have also been conducted in the AI field, such as the Partnership on Artificial Intelligence to Benefit People and Society (PAI). The PAI was established in September 2016 to develop and share best practice in AI technology, to improve public understanding of AI, and to provide an open platform for stakeholders to discuss and participate in AI and its social impacts. Amazon, Google, Facebook/DeepMind, Microsoft, and IBM initiated the establishment of the partnership as corporate members, and its non-profit members include the U.S.A.'s Association for the Advancement of Artificial Intelligence and the American Civil Liberties Union (PAI, 2016). Subsequent members include the Japanese company Sony as a corporate member, and organizations such as the Human Rights Watch and Oxford University's Future of Humanity Institute as non-profit members (PAI, 2017). More concretely, the partnership conducts research and projects related to the safety, integrity, transparency, and accountability of AI, cooperation between humans and AI systems, and the impact of AI on labor and the economy, the social impact, and the common good (PAI, 2018).

As the analysis above shows, a variety of institutional options are available for conducting technology assessments. Technology assessments can be conducted by Parliament, the core executive of the government, sectoral ministries, R&D institutes, research institutes outside the government, or international networks. Some technology assessment activities are undertaken at the site close to policy making or decision making, whereas others are undertaken at some distance from the site of policy making and decision making, enabling wide-ranging and flexible discussion. Each country and each agent must select a framework suited to its individual context.

Points to Consider when Operating and Managing Technology Assessment

The following should be borne in mind when operating and managing technology assessment.

First, attention should be paid to the relative reduction in risk when evaluating the impacts of developments in automated systems on safety and security. Typically, the assessment of emergent technology draws attention to new risks. However, the total risk may be lower than that incurred by existing technologies, raising the question of how to communicate this point. For example, introducing autonomous driving cars might reduce the total number of accidents, but not eliminate accidents entirely. Therefore, the remaining risks may warrant attention from society. However, it is necessary to have a balanced view that considers the relative reduction of risks.

The second point is exemplified by the scenarios discussed in reports for the Conference toward AI Network Society run by the Japanese Ministry of Internal Affairs and Communication, as introduced in Section on Scenarios and their Social Benefits and Risks: when considering impacts, it is necessary to construct scenarios based not only on a linear extension of our current society but also on alternative images of future societies, and to consider what kind of impacts may be exerted in these alternative scenarios. This raises a question regarding the kinds of image/scenario that should be considered when envisaging future societies. For example, when considering the impacts of developments in automated systems on industrial structures, or the impacts of developments in automated systems and networking on employment and inequality, these impacts must be assumed to differ greatly depending on the kind of society hypothesized. One must consider whether it is possible for people to acquire new skills and roles during that society's transition period—through retraining or continuing education, for example. Depending on the situation, it may be necessary to hedge uncertain futures by hypothesizing multiple future societies rather than just one.

Third, when evaluating impacts on automated systems, a realistic understanding of the relationship between developers and users is needed, taking into consideration the special characteristics of various fields. As evidenced in recent developments in machine learning and deep learning, in particular, the results and behavior of AI are typically determined not only by the technology, the algorithm, or the system itself, but also by the kind of dataset it has learned, making it important to understand the relationship between the developer and the user who provides the dataset. This affects how responsibility for system design is to be shared.

The fourth point is how to ensure coordination between automated systems. In particular, if the infrastructure required for the foundation of society is mutually connected with automated systems, various threats to safety and security will be amplified.

The fifth point is the need to evaluate the effects of the coexistence between users and non-users of automated systems during the transition period. During this period, problems of unfairness will arise between users of new systems and users of old systems due to their coexistence. If limited education and training opportunities are available to help people to use the new systems, the issue is not just transitional issue but also related to structural inequality.

Design and Operation of Accident Investigation Systems

Locating Responsibility, the Learning Dilemma, and Accident Investigation Systems

Accident investigation systems are another important institutional foundation for realizing the social benefits of automated systems, as briefly mentioned in the subsection "Overall Scenarios and Benefits in the Case of Japan" in relation to the New Robot Strategy.

The use of technology in society is accompanied by the social desire for penalties—identifying and punishing the party responsible—if accidents occur. However, it is also necessary to investigate the cause of an accident and learn from the accident, enabling recurrence to be prevented. The desire for punishment and the need for investigation do not necessarily contradict each other. Identifying the responsible party and imposing a punishment will deter unsafe behavior in the future and may ultimately help to prevent a recurrence of the accident. However, contradiction between the desire and the need may occur. If the investigation undertaken to clarify the cause of an accident requires those involved to provide extensive information, they may be afraid that this information will be used to impose a punishment and thus be incentivized to conceal information; as a result, learning may be insufficient to contribute to prevention, and accident investigations will cease (Shiroyama, 2004). It is difficult to pinpoint the cause when accidents occur in connection with automated systems because the contributions made by the development of the algorithms and the people responsible for data learning are intricately intertwined. It is therefore difficult to investigate responsibility.

Therefore, attempts have been made to develop accident investigation systems that are separated from a system for locating responsibility. For example, the U.S.A.'s National Transportation Safety Board (NTSB) was established to maintain aviation safety, and is responsible for investigating aviation accidents. It is separate from the Federal Bureau of Investigation (FBI), which is responsible for criminal investigations, and the Federal Aviation Administration, which carries the main responsibility for administrative penalties. The division of roles has also been clarified such that the NTSB usually has preferential investigative rights and the FBI takes the lead in investigating aviation-related crimes such as terrorism (Kawaide, 2003). In addition, the NTSB uses methods such as a party system whereby the stakeholders involved, including airline and aircraft manufacturers, are able to participate in accident investigation. This method benefits from the utilization of the specialized knowledge and expertise of the stakeholders involved, from whom information can be obtained quickly and easily. Although stakeholders may seek to conceal or falsify information that might prove disadvantageous in a lawsuit, such information would be impossible to conceal throughout the open-ended question and answer sessions between the investigation team and the stakeholders. The NTSB investigators have gained experience that allows them to easily spot suspicious behavior, and the NTSB seems to have largely avoided this problem—for example, it has drawn up factual reports based on all members' reports and extracted statements without bias from the statements of the specific stakeholders involved (Shiroyama et al., 2003).

In Japan, an Aviation Accident Investigation Commission was established in 1974 as an auxiliary organ of the Ministry of Transport, and due to revisions to the Act for Establishment in 2001, the Aircraft and Railway Accidents Investigation Commission was established as an auxiliary organ of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). The commissions have since sought to improve the ministries' ability to investigate the causes of aviation and railroad accidents to prevent recurrence. As a result, the Aircraft and Railway Accidents Investigation Commission was reshuffled, and in 2008, it was decided that the Japan Transport Safety Board would be established as an external bureau of the MLIT (Uga, 2010). In the Act of Establishment of the Japan Transport Safety Board, investigating the causes of accidents and preventing recurrence were explicitly stated as the purposes of the board's establishment. The Japan Transport Safety Board was established as an independent administrative committee based on Article 3 of the National Government Organization Law (Article 3: Board). The board chairman and board members are commissioned by the MLIT with the consent of both houses of parliament.

However, the management of this accident investigation commission has led to a system for reciprocal collaboration between accident investigation commission and the police when responding to accidents. The jurisdiction of the accident investigators is not clearly separated from that of the police, but the police ordinarily take the lead and collaborate with the accident investigation commission as long as this does not "impede the criminal investigation." This standard operating procedure maintains the previous system even within the Japan Transport Safety Board.

Accident investigation systems have also been set up to address medical error. In the U.S.A., a system of adverse event reporting and a system of incident reporting in hospitals constitute mechanisms for information sharing on accidents and incidents. The appropriation of this peer-reviewed information for civil cases and administrative measures is restricted. The use of reports of adverse events is protected from discovery under civil cases, and even the administrative use of reports of adverse events is limited.

In Japan, the need for a system of medical accident investigation has long been controversial. In 2008, a general outline of a proposed Act for Establishment of the Medical Care Safety Investigation Commission (provisional name) was publicized. This general outline affirmed that the goal of such a medical accident investigation would be to prevent medical errors and investigate their causes, not to investigate the responsibility of medical personnel. It was also announced that a central commission and regional commissions would be established to investigate medical care safety; the commissions would be composed mainly of health personnel, but would also include lawyers and patient representatives. However, this proposal was strongly opposed by doctors and was not realized. Later, in 2014, the Medical Service Law was enacted, and a Medical Accident Investigation System has been in effect since 2015. Under this system, any error identified by a medical institution is reported to the Medical Accident Investigation and Support Center. Then basically a medical institution carries out an accident investigation with support from the Medical Accident Investigation Support Group. This system is more heavily weighted than the previously proposed act toward internal hospital accident investigations.

Designing Accident Investigation Systems for Automated Systems

Investigating accidents connected with automated systems is more difficult, because it is necessary to consider the contribution not only of the developers and users of particular devices, but also of the program algorithm developers and the people in charge of data learning, as described above. In addition, it is important to determine how to structure mechanisms to accommodate learning in accident investigation, requiring a collaborative approach that is somewhat separated from the investigation undertaken to locate responsible parties.

To this end, the first challenge is to effectively structure accident investigations connected with automated systems. Each field of use has a related mechanism, such as the Japan Transport Safety Board or the Medical Accidents Investigation System. However, in the context of automated systems, cross-sectoral accident investigations may be set up and carried out across fields. This leads to the question of how to design accident investigation systems for automated systems combining accident investigation in each field of use with cross-sectoral accident investigation.

Second, automated systems that involve various non-governmental stakeholders raise the issue of how to promote learning—not just in accident investigations at governmental level, but also in information sharing and accident investigations at non-governmental level. Interestingly, regarding the responsibility of non-governmental trade associations, nuclear safety is ensured in the U.S.A. through the Institute for Nuclear Power Operations (INPO), which represents the proactive participation of the chief executive officers of electric power companies and manufacturers. Member companies voluntarily give the INPO incident event reports and information on equipment failures, and the INPO analyzes this information. As well as using the results to optimize the safety systems of each company, the INPO provides the government with feedback on matters such as the formulation of safety regulations. However, the original information is not shared with the public. Although non-government organizations have argued that information shared between INPO members should be made available to the public, the courts have recognized that to facilitate information gathering, certain information must be withheld from the public. The INPO has also introduced mechanisms for changing insurance premium levels based on the results of the INPO's evaluations of companies' safety systems. Rees analyzed the INPO's autonomous regulation mechanisms and characterized them as a form of "communitarian regulation," which differs from existing regulatory approaches (Rees, 1994).

Human resources are also important for the management of systems related to accident investigation. Accident investigations require not only specialization in a particular discipline, but also expertise in managing and operating investigation systems (expertise in the management of diverse members of investigation teams and the coordination of experts in different disciplines).

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CHAPTER 4

The Cultural Impact of Automation: Quality of Work and Life Redefined

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The Cultural Impact of Automation: Quality of Work and Life Redefined

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Introduction

IBM's introduction of System/360, the first mainframe computer, in 1964 initiated the modern age of computing, ushering in rapid advances in digital communication and transforming the way we interact with information. Now, we are on the cusp of the Fourth Industrial Revolution, which will revolutionise the very fabric of modern life at an unprecedented scale and speed. With the development of the Internet of Things (IoT), a network of Internet-connected objects able to collect and exchange data using embedded sensors, more personal data are in the hands of corporations than ever before. Combined with intelligent machinery, advanced robotics and global interconnectivity via personal electronic devices, the controllers of this data are able to predict and influence every segment of our society, from economics and politics to our private lives. Driverless cars, remote work arrangements, fully automated factories and managerless companies are no longer ludicrous ideas of the far future.

Digital automation will trigger a fundamental restructuring of work, from the foundational structure of companies to the new roles of managers and employees alongside their robot colleagues. A November 2017 report by the McKinsey Global Institute found that at least one third of the required tasks for approximately 60% of occupations could be automated (Manyika et al., 2017). Managers and employees alike will take on a whole host of new duties amidst a completely different work environment, as project-based employment, flat hierarchies and flexible work systems become increasingly common. Permeating all levels of modern society, digital automation is one of the most urgent concerns facing businesses today.

Research assistant Christina Yourim Ko, a student at the Graduate School of Business, Seoul National University, helped this research project with data collection for about a year.

The Impacts on Managers

Managers must challenge convention and constantly abandon or adjust existing practices

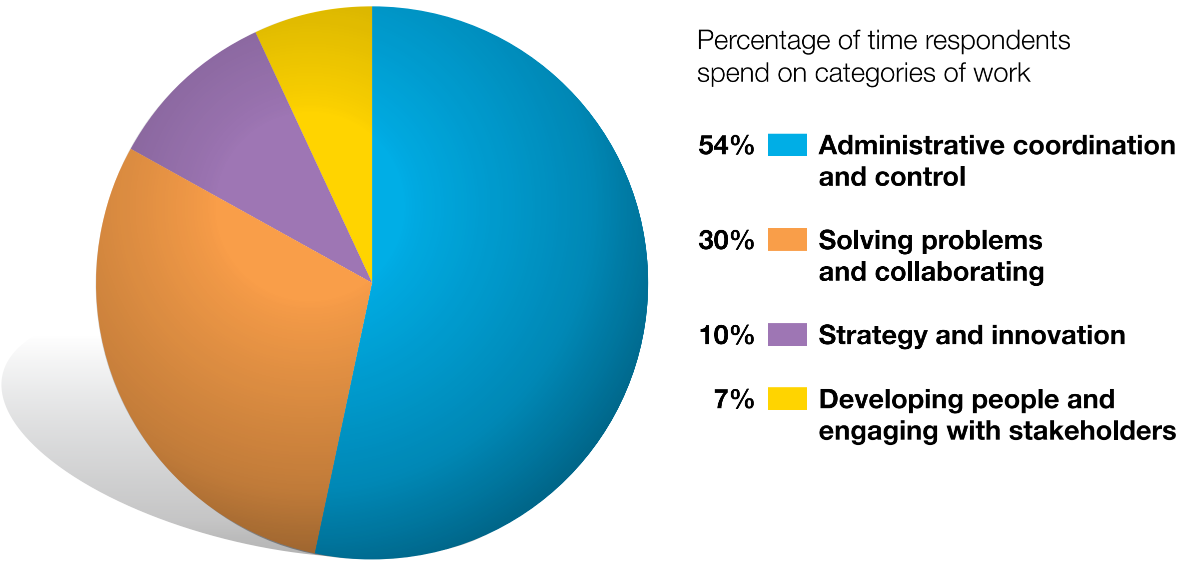
With so much uncertainty and change, no single standardised method will work for everyone. However, challenging conventions will be a common practice among successful managers. Many of the organisational conventions that still dominate companies were developed long before digital automation was even within the realm of possibility and successful managers must question whether they are still effective in the age of AI (Morgan, 2014). For example, does the nine-to-five workday still hold merit? Do the current team structures maximise creativity? Why do mentorship programmes designate the more experienced employee as the mentor and the less experienced employee as the mentee? In this age of constant change, can 'reverse mentoring' programmes where junior employees educate their seniors on modern thinking and technologies better promote innovation (Meister and Willyerd, 2010)? Many prominent, forward-thinking companies, such as IBM, already have such formal programmes in place (Chen, 2013). Such programmes not only help to establish a flow of information throughout the company, but also build relationships that transcend organisational hierarchies (Murrell et al., 2009). Implementing a reverse mentoring programme, even if for a single unit or project, may also set the groundwork to 'flatten' organisational structures, which may prove vital to improving organisational agility. Success will be the result of constantly questioning existing practices and seeking to be one step ahead of, rather than retroactively reacting to the rapid changes encroaching on every industry.

The right mind-set with which to enter the Fourth Industrial Revolution is not to view digital automation as a threat, but rather as an opportunity to upgrade what we can achieve by working together with intelligent robots. After all, automated technology can only replace a part of a human's job – specifically, the less cognitively challenging aspects that require little creativity and can be codified (Davenport and Kirby, 2016). With more time available to focus on work that requires high-level thinking, humans may be able to accomplish feats that were previously impossible. By constantly seeking to improve organisational practices, managers can identify the processes, roles and systems that can be enhanced to help push the limits of what can be accomplished to new heights.

Many traditional managerial duties will be automated, shifting the focus towards judgment work

There is no question that the roles of managers, frontline, middle and executive, will change dramatically. A McKinsey Global Institute report states that up to 25% of a CEO's tasks can be automated (Manyika et al., 2017). Indeed, managers currently spend 54% of their time on administrative coordination and control (Kolbjørnsrud et al., 2016). They also spend a substantial chunk of time – 30% – solving problems and collaborating. A significant portion of the tasks in these areas have been and will continue to be automated, as they are routine, require little creativity and can be accomplished much faster with AI. For example, administrative tasks, such as scheduling, monitoring, resource allocation and reporting, will be some of the first tasks to be handed off to machines.

Figure 1: How Managers Spend Their Time
The Bulk of It is Spent on Administrative Tasks



Source: Accenture survey of 1,770 frontline, mid-level, and executive-level managers from 14 countries

The Associated Press has been publishing robot-written earning report stories since 2014, expanding its offering from 300 stories to 4,400 (Kolbjørnsrud et al., 2016). However, instead of closing the door on human reporting, doing so opens a window of opportunity for more meaningful work: 'I can't have journalists spending a ton of time data processing stuff. Instead I need them reporting', said AP Managing Editor Lou Ferrara (Beaujon, 2014). As intelligent bots take on formulaic reports, human journalists will be able to delve into more complex tasks, such as investigative journalism.

With the automation of so many areas traditionally helmed by management, managers must seek new ways to create value in ways that are uniquely human. The type of work at which humans still outperform machines can be broadly categorised as judgment work: tasks that involve synthesising experience, discretion, empathy, improvisation and an understanding of organisational history and culture to make decisions that reach beyond simply interpreting data (Kolbjørnsrud et al., 2016). AI can analyse data at a speed and efficiency unsurpassable by humans. However, with the reports written and solutions suggested by AI, human workers can extract the insights behind numbers and facts and devise creative solutions.

A prime example of how new technologies are augmenting, rather than diminishing, human labour is human resources. Intelligent algorithms are used to sift through applicant data, from screening resumes for relevant experience and estimating the length of their tenure at the company if hired to analysing employee interactions and suggesting workflow improvements (Hyacinth, 2017). Algorithms are also emailing candidates' references with questions about the candidates' past professional performance and AI-enabled chatbots are performing initial screenings and scheduling interviews (Lewis, 2017). Beyond interacting through text, new methods such as voice profiling are replacing the customary phone screenings with job applicants in some organisations, on the basis that energy and fundamental frequency can be analysed to determine an applicant's suitability for a job. Jobalign, a candidate engagement platform, uses intelligent voice analysis algorithms to determine whether a voice is trustworthy, engaging and appropriate for the job in question (Hyacinth, 2017). However, all of these functions will ultimately serve to facilitate, rather than negate, the need for a human to make the final decision. Most intelligent technologies only automate the preliminary stages of the job recruitment and human management process.

Managers currently devote only 10% of their time to strategy and innovation and 7% to developing people and engaging with stakeholders (Kolbjørnsrud et al., 2016). However, these are the areas managers must focus on expanding for success during the Fourth Industrial Revolution. With digital assistants handling other duties that require less judgment, proactive managers must identify which innovative technologies would provide competitive advantages and devise well-planned strategies to implement them successfully. Furthermore, managers must also begin dedicating much more than just 7% of their time to enhancing their relationships with people. The importance of social skills will be discussed in more detail later in this section, but it is important to note that building genuine connections with people will make for much more fruitful partnerships. With the exponential rate of change, workers will have to constantly encounter new challenges, technologies and people and to produce stellar results even with less time to build trust and rapport.

Managers must learn to lead a hybrid workforce

A hybrid workforce is no longer a plot point in science fiction. It is our reality – if not today, in the very near future. Managers will oversee a combination of humans, robots, algorithms and intelligent systems and will have to learn how best to delegate work, measure performance, troubleshoot and mentor. Of course, managers must understand both how their new nonhuman workers function and how their human workers are feeling and act accordingly, but they must first strengthen organisational culture to maintain cohesion through this transition. Robots do not have feelings, but human workers may certainly feel insecure or anxious. The core culture must remain human-driven, catered to helping humans adjust to the plethora of unsettling changes as both business processes and colleagues become automated. A strong organisational culture instils solidarity and unites everyone in the same values and goals.

According to experts, such as Ray Kurzweil and Stephen Hawking, we may soon reach a point of singularity – when the exponential growth of technology reaches the point at which technological progress becomes unbounded (Potapov, 2018). This concept is frequently associated with the point at which AI systems will equal or even transcend humans (Michelman, 2018). Certainly, this point is not in the immediate future, but it is a possibility managers must keep in hindsight, as its effects are expected to be felt even before we arrive at the point of singularity. Higher-level managers are relatively safe from elimination, as the increasing complexity of business situations require skills even the most advanced of bots cannot master for the time being, such as being creative, providing emotional support and building relationships to maintain a sense of. However, as previously mentioned, many of the administrative, less cognitively demanding duties usually held by mid-level managers are already being automated. Some experts, such as Sidney Finkelstein, professor of strategy and leadership at the Tuck School of Business at Dartmouth University, have gone so far as to suggest the 'extinction' of middle managers (Hyacinth, 2017). Even employees who withstand the wave of displacement may believe their positions to be in danger or feel survivor's guilt. Managers must remain cognisant of this and display compassion, reminding employees they are valued at the company.

Fostering productive, congenial working relationships between human and nonhuman workers may also prove challenging. Managers' knowledge of their workers' psychology is crucial in determining how best to introduce bots to human workers and to emphasise they are helpful tools to augment human work, rather than threats. Employees and managers alike should also remind themselves that digital is not inherently better and periodically measure the benefits. Identify points in the process that still require human intervention to prevent mishaps, as complex systems can also produce errors and troubleshooting may end up costing whatever gains in efficiency have been achieved (LaPlante, 2017). Companies, such as CloudMinds, have begun attempting to simplify robot process optimisation. The Chinese start-up connects intelligent bots to a cloud AI intelligent system through which bots can be securely trained and controlled (BusinessWire, 2017). Finally, managers should push both their employees and themselves to constantly improve upon their skills. Current technology is advancing at an unprecedented, exponential pace. High-level managers will not always be irreplaceable unless they keep abreast of new developments.

Managers will be increasingly pressured to be the core strategy designers

Successful managers must not only be creative, but also effectively mobilise the creativity of others, combining ideas to build comprehensive, innovative and workable solutions. In this day and age, technology is an indispensable part of a manager's creative vision. Prudent managers should recognise that technology is the driving force behind nearly all successful and revolutionary products and services. CEOs such as Larry Page of Alphabet, Inc. and Jeff Bezos of Amazon are not successful merely because they are the chief product designers; managing the algorithms that underpin their services – search engines, ecommerce platforms that suggest products for purchase and relevant advertisements – is a core component of their jobs (Michelman, 2018). To design for the consumers of today and tomorrow, managers must be deeply knowledgeable of emerging technologies that can be used to bolster their offerings. Amazon has an excellent system in place, utilising technologies that address their commitment to their customers. Algorithms suggest what customers should buy based on theirs and other customers' past purchasing patterns and customers also have the chance to read product reviews on Amazon if they are on the fence about a purchase.

In a world where change will be the only constant, managers must be acutely aware of their customers' needs and desires, designing and continuously adjusting their offerings accordingly. Many of the businesses that are currently leading the digital transformation have developed via a build-measure-learn mechanism, starting as an intriguing, innovative concept and improving over time with more usage. For example, Uber presents the alluring possibility of summoning a car effortlessly with a smartphone, which laid latent in smartphones for years. Uber took the idea and developed it into a trailblazing service that has disrupted an industry, which was largely uninterrupted for decades. Since its inception, Uber has added different categories of cars for customers willing to pay different amounts, an in-app tipping feature and a 911 button for emergencies, among other features, to create a seamless, holistic experience.

However, the implementation of the latest technology is not the lynchpin of Uber's success. It is strategy. Even if the technologies are as state-of-the-art as they can be, nothing compensates for poor strategy, which machines still lag behind humans at devising (Hyacinth, 2017). Impressive technologies still need to be accompanied by a clear, well-thought-out strategy that clearly defines the problem to be solved, the objectives, the market gains and the added value to consumers. Being able to fulfil all of these duties rests entirely upon how deeply engaged the manager is with the customers' needs and wants, how well the manager understands the metrics that define success in the age of AI and how effectively the manager designs a creative, comprehensive and well-directed course of action.

Managers must build collective intelligence systems

Developing systems that can handle the unprecedented scale and complexity of the data sets that we encounter now and in the years to come is a major challenge (Hyacinth, 2017). Two competing systems are often discussed to fill this void: superintelligence and collective intelligence (Helbing, 2015). Superintelligence consists of an enormously powerful being or system that possesses access to all of the knowledge and resources necessary to be a superintelligent, near-omniscient being who is the sole decision maker. Collective intelligence involves a collaborative effort: leveraging the intelligence of everyone in the company, allowing teams with varying methodologies and perspectives to develop solutions independently and then combining these diverse solutions to arrive at one that is as close to the best solution as possible. In many ways, superintelligence will continue the tradition of top-down decision making by a select few, except probably with an intelligent robot boss rather than a human one.

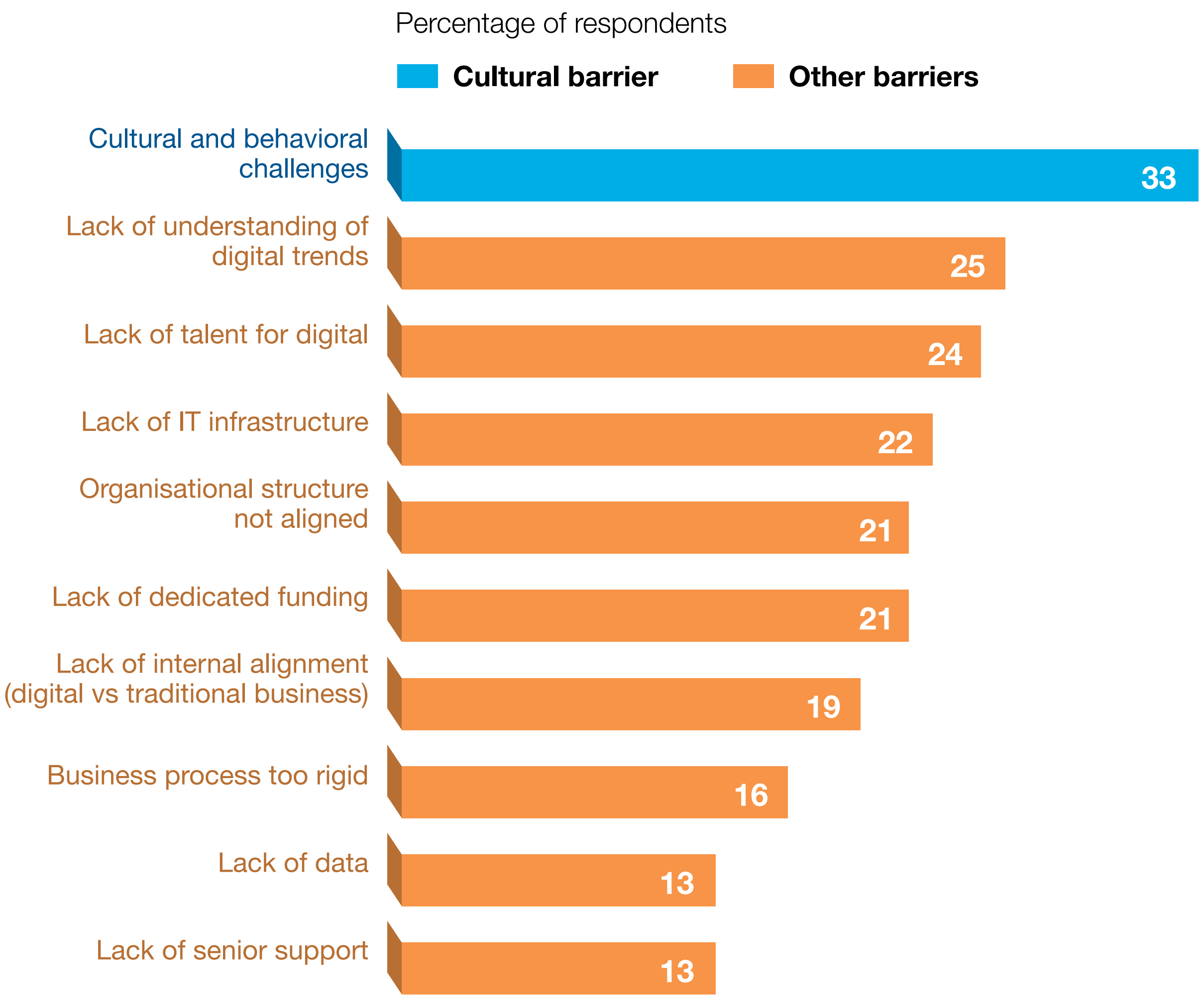
However, the current business environment is so complex and diverse, it would be foolish to hold a single person or intelligent machine accountable for completely understanding and managing all of the details. In the face of seemingly insurmountable complexity, a diverse range of specialised solutions wins over a single, brilliant solution. This seemingly counterintuitive notion is illustrated through the results of Netflix's 2006 open competition, which challenged teams to discover a means to improve the streaming service's predictive algorithm for movie ratings by 10% or more. However, of the 2,000 teams that participated, not one was able to produce a 10% improvement with just its own solution. However, when the team whose algorithm came closest to improving predictions by 10% averaged its findings with those of lesser-performing teams, the predictive ability of the average of the algorithms was greater than that of the winning algorithm alone (Helbing, 2015). No single solution could identify all of the patterns in the data set. The top teams, although they each came close to achieving the 10% improvement, all discovered different patterns in the data and consequently chose different problem areas to target. When combined, the solutions filled the gaps that formed when only one algorithm was implemented and neutralised the errors of each individual solution. Perhaps an even more surprising revelation was that the ability of the average prediction was unaffected by the weight assigned to each of the algorithms. Even when better algorithms were given more weight than inferior ones, predictive ability did not improve. As no single algorithm was perfect, the average of all algorithms, regardless of their accuracy, was superior to all other alternatives. These results yield a key insight into how we should approach big data: diversity, specialisation and the incorporation of various solutions are key.

Collective intelligence, allowing us to harness the best skills and expertise from a diverse set of perspectives, can exceed the intelligence of even the brightest people or supercomputers. Such a system also incorporates weak ties into the decision-making equation, increasing the diversity of perspectives. Managers previously relied on the opinions of people in their direct network – people who had strong ties to them and probably had similar beliefs and ways of thinking to the manager. With collective intelligence, lower-level employees with weaker ties to the manager could have their voice heard just as much as those with stronger ties to the manager. After all, as proven by the Netflix competition, their opinions are no less valuable. In the face of big data, diversity, specialisation and the convergence of multiple viewpoints are key to obtaining the best solution possible.

Social skills will become the most important managerial skills

To produce collective intelligence, managers must ensure that employees do not feel isolated but are connected to a social, collaborative and participatory environment in which everyone feels engaged, valued and eager to contribute. Companies must integrate social platforms into their culture and managers must abandon the age-old habit of retaining information among themselves and other high-level employees.

Figure 2: Culture is the most significant self-reported barrier to digital effectiveness
Which are the most significant challenges to meeting digital priorities?



Source: 2016 McKinsey Digital survey of 2,135 respondents

For sharing to be effective, there must be value and context, with ample information for employees to first learn about the issue to form opinions and suggestions. When people engage in meaningful conversations, they build relationships, which builds trust. In turn, when people feel connected, they feel a personal attachment to the goals of the company. This results in engaged employees who consider innovation as not only management's job, but also something they can and are excited to help foster.

In addition to strengthening allegiance to the company, opening up discussion to all employees produces a much larger, more diverse set of potential solutions. Both from the much wider variety of ideas and the numerous combinations that can result from a larger set, it will be easier to generate more novel combinations and differentiate them from those of competitors. Furthermore, when several ideas are combined to produce the overall solution, many winners are produced, keeping morale high among multiple groups, rather than just in a single winning group (Helbing, 2015). This makes everyone feel as though they are a part of the solution. For example, change projects have a dismal rate of success, with 70% of them failing globally, and unless charismatic leaders are able to unite their workforce with a vision and build corporate culture fit for the challenges ahead, digital transformation will fail too (Hyacinth, 2017).

The Impacts on Employees

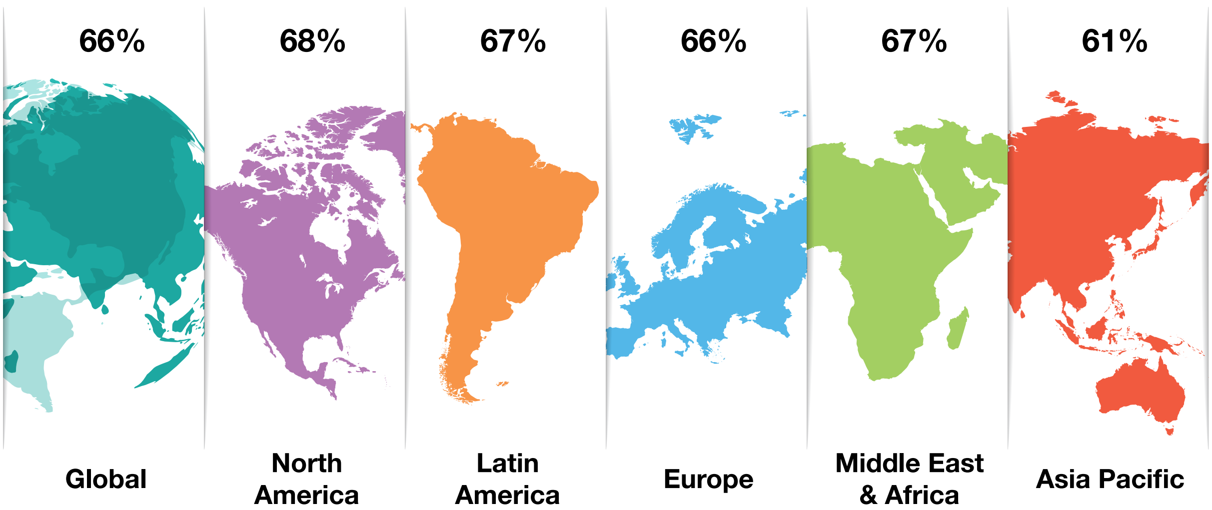
Having no power over employment decisions, employees may feel more vulnerable to the disruptive effects of digital automation than managers. It would be meaningless to deny the transformative effects of digital automation and the rapid and large-scale displacement it brings. However, incorporating intelligent systems, data sets of unprecedented size, automated technologies and robotics into virtually all industries will create exciting new professional opportunities and social benefits in all types of sectors, from manufacturing to the public sector to banking.

Nowadays, specialised engineers remotely control massive, automated factories via central control systems, instead of toiling away at the assembly lines. Adidas currently operates two state-of-the-art superfactories and plans to open more in the future. The shoes are created by digitally automated machines, which construct the shoes using data from real professional athletes and pertinent data about the city the shoes are going to be used in, to produce the perfect sneakers for customers of that city (Ismael, 2018). 'Lights-out factories', where intelligent robots make 24/7 operation and energy savings possible due to lower heating and lighting requirements, are also capable of advanced monitoring and real-time maintenance. However, humans are still critical to the operation of such factories, as demonstrated by the underwhelming performance of Tesla's robot-only factory. Specifically, a study of AI systems found that the combination of humans and robots maximises performance gains (Wilson and Daugherty, 2018).

Cities are also becoming 'smarter', utilising the massive amounts of data collected through IoT devices scattered throughout the city (Woetzel et al., 2018). By analysing the data, humans can build systems to solve problems, such as reducing the number of cars on the road, shortening emergency response times and dropping crime rates. As Internet connectivity is an integral foundation for smart city initiatives, Seoul, which has the one of the fastest Internet speeds in the world, unsurprisingly ranked among the top smart cities. The South Korean government is actively pursuing digital transformation as a national agenda. The government's R&D increased by 25.6% in 2018 (USD1.52 billion). The Seoul Metropolitan Government (SMG) also announced the Global Digital Seoul 2020 initiative in 2016, a 5-year plan to develop Seoul into the leader of e-governance. The SMG has taken a number of steps to become smarter, including hosting the Seoul Digital Summit every year since 2016. The summit brings together representatives from other key 'smart' cities around the world and national and foreign corporations. The summit aims to foster cooperation among these key players to device policies that harness new technologies to better citizens' lives. Such initiatives will create a variety of jobs that not only fulfil new needs, but also require workers to troubleshoot new problems that arise. As demonstrated by the under-population of Songdo, a smart city on the outskirts of Seoul, carefully planned urban development ventures do not always pan out as planned, necessitating humans to craft new strategies to adjust course (White, 2018).

In line with its high-tech reputation, South Korea has also produced a star player in the booming financial technology industry, Kakao Bank. Capitalising on its nearly 40-million chat user base, Kakao Corp's Internet-only bank, only the second in Korea, acquired one million customers in the 5 days following its launch on 27 July 2017 and was the fastest-growing mobile bank in the world as of August 2018, with more than 6 million users, $6 billion in deposits and over $5 billion in loans issued. Although one may fear mass unemployment following the success of an Internet-only business, Financial Services Commission Chairman Choi Jong-ku predicted the opposite. Choi estimated Kakao Bank would add approximately 2,470 jobs over the next 3 years, adding that 'these innovative financial services, once activated, will create a virtuous circle and trigger a job creating effect in the market' (Bae, 2017). One thing is certain: whether you remain employed at your current job, leave voluntarily or are laid off, there will be no shortage of dramatic advancements or varied opportunities during the Fourth Industrial Revolution.

Figure 3: Too Few Infomation Security Workers in My Department

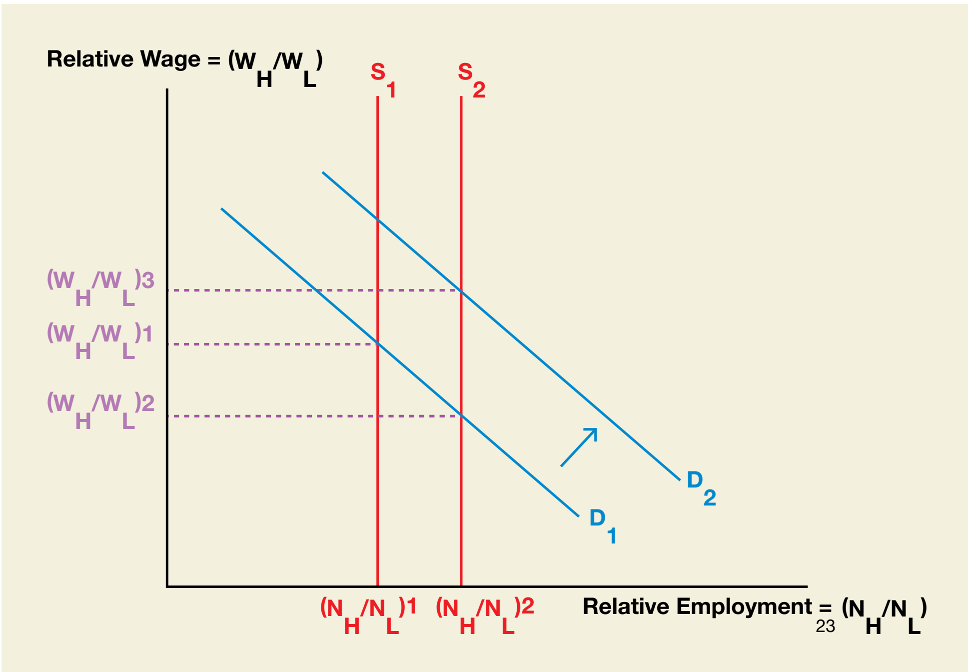


Source: 2017 Global Infomation Security Workforce Study (n = 19.175)

Although the increasingly humanoid nature of intelligent robots will eliminate many jobs, it will also create new ones unique to the age

Focusing only on the jobs that will be eliminated ignores an intrinsic characteristic of demand: that the value of whichever jobs cannot be automated will rise. As shown in the graph from the World Development Report 2019, adapted from Goldin and Katz (2008), as demand for high-skilled labour increases, wages for high-skilled workers will increase accordingly (The World Bank, 2018). Although low-skilled labourers will most likely remain stagnant, creating a larger disparity between high-paid workers and low-paid workers, there will be drastically less demand for low-skilled workers as more and more low-skill, repetitive jobs become automated. Furthermore, through both their own initiative and government and corporate retraining programmes, low-skill workers will hopefully occupy more challenging jobs and benefit from the increased wages for high-skilled occupations, for which there is overwhelming demand and inadequate supply. Even within just the cybersecurity industry, the global research and consulting firm Frost & Sullivan predicted a whopping 1.5 million worker shortage by 2020 in 2015 (Reed, Zhong, Terwoerds and Brocaglia, 2017). However, in 2017, the firm revised its estimate to an even larger figure: a 1.8 million worker shortage by 2022. Indeed, according to the 2017 Global Information Security Workforce Study, 66% of professionals globally feel as though they lack information security experts at their companies (Reed et al., 2017). To address this shortage, a third of managers all over the world are planning to increase their departments by 15% or more.

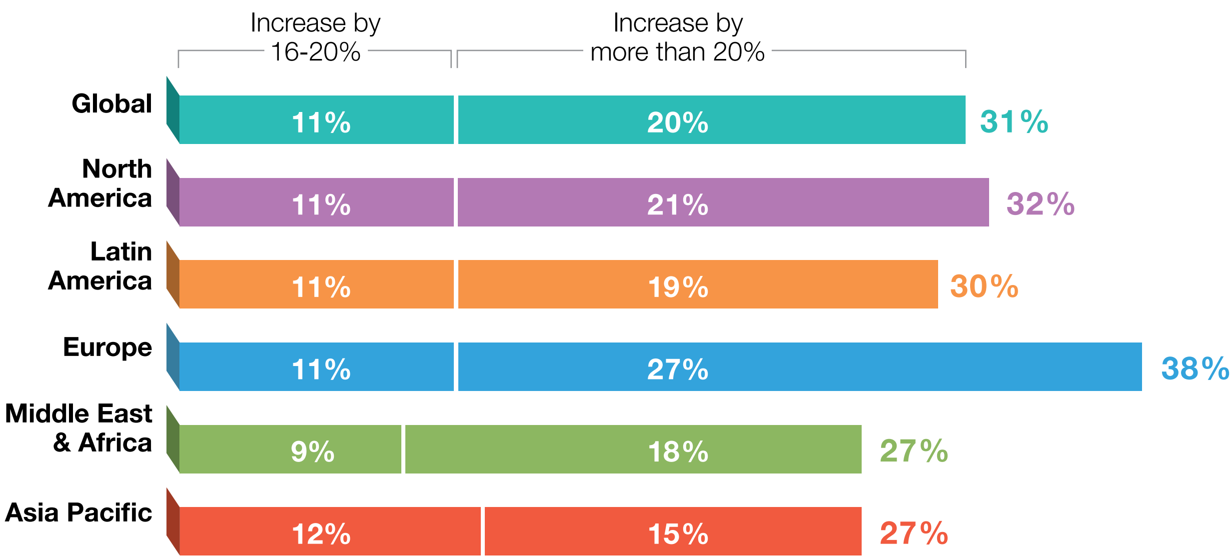
Figure 4: The Pay Gap Between High- and Low-skill Workers



Source: Adapted from Goldin and Katz (2008).
Note: As the supply of high-skilled labour increases (S1 to S2), the relative wage between high-skilled and low-skilled labour is expected to decrease [(WH/WL)1 to (WH/WL)2]. However, the demand for high-skilled labour continues to increase (D1 to D2), resulting in higher relative wage between high-skilled and low-skilled labour [(WH/WL)1 to (WH/WL)3].

Although it is uncertain whether digital automation will create as many new jobs as it eliminates overall, the Fourth Industrial Revolution nevertheless will bring exciting new opportunities for workers to take on jobs that are cognitively stimulating, never repetitive and constantly changing. A variety of new jobs unique to the future can be broadly categorised in the following three categories: trainers, sustainers and explainers.

Figure 5: Hiring Managers Expecting to Increase Workforce by 15% or More by Region (among managers expecting to increase workforce)



Source: 2017 Global Information Security Workforce Study, (n = 2,906)

Bot trainers

Those with the technical expertise to train intelligent bots, such as programmers, data scientists and IT specialists, will be highly sought after. Although there is increasing customer demand for certain types of technologies, bringing them to life requires many skilled professionals and complicated processes. For example, one of the most sought after technologies is chatbots, which answer directly to a growing customer demand for personalised products and services available conveniently through their preferred mediums and times.

Companies, such as 1-800-Flowers, The New York Times and Uber, have already begun experimenting with this technology to provide customers with bouquets, information about the 2016 US presidential elections and rides – directly from their conversations on platforms, such as Facebook Messenger, Amazon Alexa and IBM Watson (Michelman, 2018). Customers will come to increasingly expect such service, provided around-the-clock through conversational interfaces. Chatbots answer directly to this growing demand.

However, the success of conversational interfaces depends on how well bots can read the patterns in the complex communication methods of customers. Although IBM and other companies have made significant progress over the past few years, training robots how to converse is inherently difficult for two main reasons: the nuances of language processing and AI's lack of empathy. Whereas recognising that not every word should be taken literally (e.g. in the case of sarcasm) is intuitive for human workers, instilling this sensibility into robots can be a rather time-consuming process. If we account for the relatively more complex language structures of Asian countries, these kinds of tasks become quite demanding. Robots must be taught to correctly analyse each component of a potential customer's word choice, intent and emoji usage, among others. Another pitfall of intelligent robots is their lack of social and emotional intelligence. When facing customers, empathy is an especially important characteristic to display as proof of genuine interest in the customers' concerns. Teaching a nonhuman being without the intrinsic emotional foundation how to empathise and provide for others' emotional needs is a process that will require ample time, resources and a highly specialised task force.

Sustainers

For as advanced as they are, AI must still be monitored by human workers to ensure it works as designed. When unintended consequences occur, human workers must step in to resolve the problems in the appropriate manner. In the current chapter of the technological transformation, such interventions are still quite frequent. Ever-popular natural language processing technologies can be used as an example. Even with meticulous training, chatbots harbour enormous potential to turn awry. In 2016, Microsoft introduced an experimental chatbot, Tay, who could converse with and learn from users on social platforms, such as Twitter, steadily improving her conversational skills through real-life practice (Metz, 2016). However, Tay, who had been trained to have the personality of a light-hearted 19-year-old girl, barely lasted a day before she began spewing a series of inflammatory comments about dictators and rape (Martin, 2016). The conundrum with conversational bots is that they are trained using data sets – and with the abundance of offensive statements online, it is not altogether surprising that Tay morphed into a foulmouthed Internet user herself. After all, research shows that negative content not only is abundant on social platforms, but also spreads much more widely and quickly throughout social platforms than positive content (Angulo, 2018).

Source: 'Microsoft briefly reinstates Tay - the Twitter AI that turned racist in 24 hours', Alphr

Tay's downfall also illustrates another critical component of natural language processing: censorship. Developers want to give their bots ample room to develop their personalities naturally and give customers the impression they are speaking to someone who understands them, instead of a computer program that can only provide cold, impersonal comments that are hardly superior to 0s and 1s. As Tay so vibrantly demonstrated, a conversational bot without filters can be disastrous, but Microsoft's assiduously politically correct predecessor Zo, launched 6 months after Tay's demise, may not be much better, either. Zo point-blank refuses to discuss anything related to the topics her creators have deemed potentially controversial, such as Jews and Muslims, but is more than happy to converse about Christians and Biblical figures, such as Abraham (Stuart-Ulin, 2018). Zo has largely stayed out of controversy, but does not seem to have made many strides towards Microsoft's goal with both bots – to show off a personality and engage in natural conversation.

As a result of such complexities, companies dedicated entirely to organising human emotions into workable sets of data for intelligent systems are emerging. For example, New York-based start-up Kemoko, Inc. specialises specifically in providing emotional training for natural language processing systems, such as voice assistants and chatbots (Michelman, 2018). The AI system runs a series of practices for systems' digital assistants, such as Apple's Siri, to learn to respond to more complicated queries, such as helping solve a customer service problem, which necessitate displaying empathy for the customer's distress and responding with compassion. A human trainer oversees the interactions and corrects any mishaps. By repeating this process, intelligent systems learn how to better predict the appropriate response. Another start-up, based in South Korea, called Looxid Labs, gathers emotive data directly from consumers' eye movements and brainwaves while consumers watch virtual reality (VR) content from the company's VR headsets (Sohn, 2018). Looxid Labs and other companies have shared the data they collected to create better ads and AI systems. Eventually, the Looxid Labs founder hopes to create robots that not only can perform given tasks, but also are so humanoid that humans can form relationships with them, similar to the intelligent computing system from the 2013 film 'Her'.

On the whole, algorithms are still very far from functioning without human oversight. This dependence on humans stems from two main factors – biased sampling and filter bubbles. Many intelligent technologies, such as chatbots that attempt to mimic human conversation, are trained using large sets of data. Thus, the success of such data-driven systems depends on the quality of data sets. Given both the sheer amount of data available and the difficulty of being completely objective in making judgments regarding what is valid and appropriate, creating bias-free data sets is no easy task. In 2015, Google was embroiled in controversy because their algorithm, which recognised and tagged images based on their content, labelled black people as gorillas, due to their training sets of data containing not enough racial diversity (Stuart-Ulin, 2018).

Although some algorithm biases may be glaringly obvious, some are not. The emphasis on personalisation in the digital space makes it prone to filter bubbles or unique worlds of information tailored to each user, creating intellectual blind spots unbeknownst to the user (Pariser, 2012).

Much of the content we consume online has been curated for us by invisible personalisation filters whose source material is broad reaching and mostly unknown to us. Whether Google is tailoring our search results based on the items we have searched in the past, the websites we frequent, the things we share online, our physical locations or anything other personal information that lives in online databases, it is impossible to pinpoint a specific cause. What is troubling about filter bubbles is that when we choose to visit specific ecommerce stores, media platforms or blogs, we are conscious that we are entering a space with a specific point of view and motive. However, Google searches are frequently perceived to be objective and fairly standardised. In reality, they can vary vastly. For example, for one user, a search for 'BP' may produce mostly results about the oil spill, whereas for another the search may produce results mostly about investment information about the company and almost none about the spill (Pariser, 2012).

Explainers

The jobs mentioned in the previous two sections are all deeply engrained in the day-to-day function of automated technologies. However, some workers must also serve as mediators between the technological and non-technological experts. The explainers consist of three main subtypes: those who explain the technical mechanisms themselves to nontechnical works, those who explain the social consequences of decreasing personal privacy and those who explain how to cope with increasing job instability and potential mass unemployment.

In addition to AI systems being much too complex for everyone to understand fully, such systems can also be frustratingly opaque. Fewer 'smart technologies', such as robotic process automation – which is often used to automate administrative duties, such as updating customer information files – are based on simpler models, have no capability to learn and improve on their own and are fairly straightforward in their workflow (Davenport and Ronanki, 2018). However, many of the most powerful algorithms, such as deep learning mechanisms (which are being used to mimic human speech patterns), remain in a 'black box' (Hosanagar and Jair, 2018). Such algorithms are developed mostly through training data and only partially through codes and it is nearly impossible to explain the models that are created in the process, even after examining the source code and inputs and outputs. Moreover, as many of the algorithms in use are created and being used by for-profit companies, technical details are often hidden to protect intellectual property (Hosanagar and Jair, 2018). Nevertheless, we need technical experts who possess the necessary skills to analyse algorithmic reasoning and can explain, to the extent they can be explained, how the results were obtained.

The opaque nature of algorithms is particularly problematic when customers bear the brunt of the blow. With the wealth of personal data online, some companies have intentionally designed certain algorithms to behave differently towards different types of consumers. For example, the travel website Orbitz directs Mac users to more expensive hotel options than PC users, on the basis that the company's research revealed Mac users spend approximately 30% more on booking hotels than the latter group (Mattioli, 2012).

Another problematic aspect of algorithms is the attribution of responsibility, both internally in who to hold accountable for potential mistakes and prevent them and externally in how to explain the causes of mishaps to customers. Consider self-driving vehicles. In the case that an accident is unavoidable, should a car prioritise minimising damage to the surrounding environment or to protecting its passengers, even at the cost of harming others not inside of the car? Furthermore, when such an accident occurs, who is to take responsibility and compensate potential victims? (Michelman, 2018). This grey area is present even when humans are involved. Companies are also developing robots that perform data analysis to assist decision making (Kolbjørnsrud et al., 2016). If a human financial advisor assisted by a robot recommends an investment strategy that results in significant financial loss, who is at fault? Is it the robot who performed the analysis that was critical to the decision, is it the advisor who accepted the robot's results or is it the programmer who wrote the algorithms behind the robot? The codes underlying such algorithms contain the programmer's judgments on which data sets are relevant, which risks are pertinent and, ultimately, what we value. At the end of the day, what does data mean and how should it shape our lives?

Data is the basis for everything digital and companies must be especially cautious to not cross the increasingly murky boundaries of personal privacy and refrain from exploiting the wealth of personal data that they have now amassed for purposes not disclosed to consumers. Fifty per cent of consumers indicate that they are willing to pay a premium to do business with companies they trust and 57% have indicated that they would walk away from companies that have betrayed their trust (Bahl, 2016). Steps have been taken to tackle the transparency issue, but much more must be done. In May 2018, the EU began enforcing the General Data Protection Regulation, which states that consumers have the 'right to explanation' and are able to question and protest against any decision based purely on an algorithmic basis (Michelman, 2018). Although users can now demand the data that companies use to determine which products to recommend and which advertisements are shown, the technical challenge of transparency remains unresolved (Hosanagar and Jair, 2018).

Lastly, we also need social scientists who can explain how to solve the mass unemployment problem that may result from digital transformation and psychologists who can provide help to those who are affected. Although many workers should be able to adjust to the changing requirements, not everyone is fit for technical work. It may be significantly more difficult for people in low-intelligence jobs, such as construction work, to retrain themselves technically. Regardless of their skills, older people may face more difficulty overall. Age discrimination occurs to workers as young as 45, particularly in technology- and knowledge-driven fields (Hyacinth, 2017). Some experts also question whether companies of the future, with so many algorithms and smart technologies to assist them, will need many workers. Many successful digital companies, at the time of their acquisition by tech behemoths Google and Facebook, had a small workforce: YouTube had 65 employees, WhatsApp had 55 and Instagram had just 13 (Pulkka, 2017). It may be that even if workers know and possess the skills necessary, only the most talented are hired. Those who can devise policies and social programmes to mitigate such problems will be in high demand.

Workers will more closely resemble associates, rather than employees

Our association to companies will be weakened by two main factors: the proclivity of companies to hire staff on increasingly rolling, short-term contracts and the availability of entrepreneurship opportunities to employees.

Changing hiring patterns

Work will become increasingly project based and companies will find it much more efficient to hire based on their specific needs per project for three main reasons. First, instead of being bound to a specific company, workers will increasingly prefer to work on a freelance basis (Manyika et al., 2016). Second, as more and more aspects of work are automated, work can be outsourced much more easily. Third, more specialised, local knowledge is required for the problems of tomorrow, making recruiting employees with the specific skill sets needed for different projects more effective than continuously feeding oncoming projects to the same team. Dividing work on a project basis will also allow companies and other large institutions to respond more flexibly and quickly, taking on projects to troubleshoot specific problems or complement their existing activities.

As we will constantly encounter new projects and new colleagues, our relationships to institutions will become increasingly defined by the activity in which we are engaged at any given time. Instead of staying in permanent teams, the ability to quickly and effectively realign oneself with various causes and groups of people will be a prized quality (Michelman, 2018). Michael Bernstein, professor at Stanford and leading crowdsourcing expert, predicts that 'flash teams' – which are task-driven, supported by digital assistants, short-lived and very flexible – will be a common component of the workforce (Michelman, 2018).

Consequently, companies are employing their staff on rolling, short-term contracts or arrangements. A growing percentage of the workforce already works on a temporary basis. For example, Amazon Mechanical Turk enables companies to easily outsource certain tasks to a casually employed workforce (Schmidt and Jettinghoff, 2016). For most tasks offered through the site, the working relationship between employer and employee often lasts just a few minutes (Hyacinth, 2017). In the United Kingdom, approximately 800,000 workers are on 'zero-hour contracts', which puts them on call for an employer but does not guarantee them any working hours within a set timeframe (Manyika et al., 2016). It is more difficult to build a sense of belonging to a team and cohesion among employees if employees are constantly switching between different teams and companies. Furthermore, if workers are paid per project and/or per specified short-term period, then loyalty may decrease. In the future, it may become even more common not to expect as much company loyalty as we do now.

Availability of entrepreneurial platforms

The plethora of new platforms that allow employees to set up entrepreneurial projects will further weaken the contract-based relationships between companies and employees. Digital platforms and tools have significantly lowered barriers to entry to entrepreneurial spaces, creating large-scale networks of workers and clients from all over the world that can be accessed within a few simple clicks. With detailed, real-time information on both parties involved in the transaction, search algorithms on freelancing websites make it easy for users with mutual goals to find each other. Finally, freelancing platforms, such as Upwork, TaskRabbit and Freeelancer.com, often store information on past projects and provide ratings or reviews of their users, guaranteeing high-quality interactions (Manyika et al., 2016). In addition to performing their usual professional duties without intervention from a company, platforms such as Etsy and Airbnb, allow users to sell products or rent out assets (e.g. spare rooms) for profit.

In addition, certain digitally driven, entrepreneurial opportunities not only are profitable, but also turn ordinary people into celebrities. In South Korea, popular broadcast jockeys (BJs) of the live streaming app Afreeca TV garner legions of fans and make millions of won per video from broadcasting whatever they wish largely without regulation. Afreeca TV is the most popular live streaming platform in Korea and hosts, most of whom do not have professional broadcasting experience, can air their content anytime, anywhere (Han, 2017). Content is largely unregulated and can vary from eating takeout meals and studying silently in front of the camera to pranking unsuspecting pedestrians and playing raunchy games (Yoon, 2017). During these live broadcasts, a live chat function allows viewers to send messages and 'star balloons', or donations, to hosts. Afreeca TV also pays its top-performing hosts in addition to the donations they receive from their fans. BJs and Afreeca TV are reticent about their profit, but according to data that have been released, the top Afreeca TV host earned 298 million won (approximately $260,000) in 2013 and a middle school student who eats fast food in front of his camera earned 2 million won (approximately $1,700) for his most lucrative episode in 2015 (Yoon, 2017).

Communication skills will be the core of any occupation

Amidst all of these changes, an employee's ability to communicate with all possible stakeholders and third parties will be of critical importance. Whether they choose to remain in a company or take on entrepreneurship, it will nevertheless be crucial for employees to communicate effectively in social, emotional and business contexts.

Within companies, individuals will need to excel at tasks in which intelligent robots cannot match their performance, such as simultaneous communication in multiple contexts. As mentioned previously, employees must hone in on the skills that are uniquely human, with communication being one of the key areas of strength humans still hold over intelligent technologies. As more and more tasks are automated, the ability to establish and sustain human connections with customers will be even more sought after. For example, with the introduction of ATMs, many predicted the demise of bank tellers. However, human workers at the bank are able to go beyond the data to provide compassion, tailored advice and relevant personal experiences, building a meaningful relationship that encourages consumer loyalty (Michelman, 2018). In a sea of automated chatbots, employees and companies who can still make the interaction feel human and personable will have a competitive edge over those who do not.

Also, idea sharing on communication platforms will be a core component of work culture. The employees who are valued will not simply the ones who arrive at work on time every day, work in their workspace and report to their bosses dutifully. Through sharing platforms, everyone's contributions will be visible to everyone else in the company. Due to the visibility of these contributions, being able to communicate ideas in clear and socially and emotionally effective ways will be ever more important. People who contribute meaningfully in these visible ways will earn respect and become leaders even without holding official leadership titles. In addition to gaining recognition in the workplace, workers must also have stellar communication skills to seek out entrepreneurial projects on their own. Each freelance worker will essentially function as a self-operating small business, acquiring and managing relationships with clients effectively to maintain a steady stream of work and income (Manyika et al., 2016). Furthermore, client-worker interactions on these platforms will almost always take place entirely online, meaning workers will not have the advantage of speaking face-to-face and appealing to potential clients with their body language. Instead, they will have to develop rapport solely through online communication.

The ability to learn will be prized over existing knowledge or experience

At the speed intelligent machines are learning, knowledge and experience will progressively hold less and less value. Workers can no longer rely on their past experiences and training to be successful in the years to come. In Korea, children are learning coding as early as preschool. With a generation of children growing up learning the latest technologies, prior knowledge and training will become constantly out-dated and continuous learning will be an inseparable part of any type of work. Our world has become too complex for rigid systems, bots or individuals. Continuous learning will empower the workers of the new age to be as adaptable as they need to be.

Workers will be hired based on their ability to think, rather than the knowledge they possess – they will constantly need to learn new knowledge to keep up with the pace of innovation. Today's education systems have not prepared workers for the challenges they will face as the exponential growth of AI increases evermore – perhaps educational systems are yet another institution that are too rigid, bureaucratised and large to respond quickly to change.

Furthermore, a high-level understanding of the changes coming from the Fourth Industrial Revolution will help you to not only understand where risks to your career may come from, but also identify opportunities for your future (Hyacinth, 2017). Not everyone can become an indispensable expert on AI, but everyone can become a much improved version of themselves in their current jobs that make them difficult to replace, or at least delay their replacement (Hyacinth, 2017). Workers should also pay attention to areas indirectly related to their careers and other areas where their skills are applicable. One must create every advantage to stay ahead. No one can predict for certain how occupations will evolve. In the future, workers will need to create new value via the random combination of a variety of knowledge areas. Consequently, workers who can quickly obtain and utilise knowledge of a completely new discipline will be highly sought after.

Employees will have the power to customise their careers

The idea of a lifelong career and moving up a hierarchy of similar jobs at similar companies is no longer pertinent. Employees staying at companies long-term is now virtually unheard of (Jacob, 2014). Also, even without the external threats to their career path via new technologies, it has become much more common for workers to be loyal to the people they work with, rather than the companies they work for. When the co-workers they have developed productive working relationships with move to different companies, many employees follow those co-workers to their new companies.

Many prominent companies have established formal programmes that encourage employees to take charge of their careers. Consulting firm Deloitte prides itself on having a career customisation programme in which employees can shape their individual work lives in a number of ways, such as deciding how many vacation days to spend, and can choose to apply to move laterally within the company. Valve, a $4 billion dollar video game company, explicitly states in its Valve Handbook that it is the employees' job to find their purpose at the company: 'You were not hired to fill a specific job description. You were hired to constantly be looking around for the most valuable work you could be doing. At the end of a project, you may end up well outside what you thought was your core area of expertise' (Valve Corporation, 2012, p.9). Certainly, the coming years will be a time with much less guidance and much more uncertainty. However, for the employees who are prepared and proactive, it will be an exciting new era with multiple ways to success. With the diminished bond between employee and company, project-based work patterns and entrepreneurial opportunities, workers will have every opportunity to shape their careers into what they wish them to be.

The Impacts on Corporate Culture

Top-down governance will become obsolete

Top-down governance may no longer be effective for a number of reasons. The current world is too complex and top-down decision making is much too narrowly focused and rigid to respond effectively to today's challenges – and even more ill equipped to respond to the challenges of tomorrow. Effective and efficient approaches must be much more innovative and tailored to specific local needs. To do so, a diverse range of perspectives must be considered to minimise errors and identify as many pertinent patterns in the data as possible. As demonstrated by the aforementioned Netflix competition, a single solution, regardless of its quality, simply will not be enough in the face of big data. In addition, managers no longer have the expertise to be able to make decisions without consulting a technical expert. Currently, optimal solutions are being sought within teams, departments and functions, but with AI, big data and real-time networks, it will be necessary and feasible for workers and customers alike to develop single activity optimisation processes.

Entrepreneurship, distributed leadership and the continual reorganisation of people and resources will characterise the Fourth Industrial Revolution. Many problems are too complex to be solved in real time by a hierarchy, even with supercomputers. This limitation is exacerbated by the improvement rate of processing power lagging behind the growth rate for big data. The former will double every 18 months and the latter will double every 12 months (Helbing, 2015). If we take a top-down approach to analysing big data problems, we risk falling under the flashlight effect. Without examining the problem at hand from multiple different viewpoints, it will be nearly impossible to grasp all parts of the data. Instead, we should simply shine a flashlight onto certain issues our approach would be able to uncover, whereas other potentially important issues will remain in the dark. If we find out about these issues later, as they are happening, we can only be reactive, not proactive, which considerably limits the efficacy of our response.

On-going, company-wide conversations will be critical to firm success

Executives should encourage open communication within the company, utilising conversational platforms to share information with the entire workforce, rather than withholding important information among top-level employees. Managers should aim to maintain a continuous conversation about pertinent issues at the company, encouraging all employees to ask questions, share their opinions and offer solutions. There is a plethora of new platforms to facilitate open communication within the firm, from wikis and microblogs to multichannel platforms (e.g. Yammer, Slack and HipChat) and employee feedback tools (e.g. TinyPulse). On these platforms, an executive can upload an analysis of a common concern, available for anyone within the company to offer insight on. Ideas can be shared in real time, allowing for faster, more efficient collaboration.

When executed correctly, open communication can complement formal control. By allowing employees to participate in processes that were previously hidden behind red tape, employees feel a sense of gratitude and as though upper management values their views regardless of their positions on the corporate ladder. In addition, because everyone is participating in organisational decision-making, they develop a stronger sense of personal attachment to the issues being discussed. If management makes clear that dissenting opinions will not be punished, employees will be more willing to express non-traditional views. The diversity of perspectives may direct company conversations in interesting and unexplored directions that lead to new revelations and innovation. However, even within a conversational firm, managers can still remain the final decision makers. Opening up the decision-making process may even earn managers more respect for taking a variety of opinions into consideration before arriving at their final decisions. Furthermore, the company-wide consensus building process may also greatly expedite decision-making and execution.

Many companies will find it necessary to flatten their hierarchies

As discussed previously, dismantling organisational hierarchies creates an environment much better suited to responding to the challenges of AI. Many organisations will choose to flatten their chain of command, although the extent to which they implement this feature will vary depending on the type of business and its goals. Whichever way organisations go about flattening their hierarchies, the ultimate goal should be to create an environment that will empower employees, regardless of position, to openly communicate with anyone in and outside the company and to actively participate in decision making. Most of all, this structural change should make the organisation more agile in responding to change, of which there will be plenty.

In a completely flat organisation, there are no mid-level managers or no managers at all. There is no set order for power to flow and nobody sets rules or passes them down the ladder to be obeyed throughout the organisation. Everyone is on the same footing, although informal hierarchies often arise naturally. At Valve, hiring is done communally and individual employees suggest projects. Projects that gain support and participants are pursued and those that do not are left untouched. Employees who have been at the company longer tend to lead projects, as the reputation they have built makes it more likely for their projects to gain widespread approval. However, this is an informal position, rather than a formal, prescribed one. This type of structure is often seen in tech and start-up companies, but may not be realistic for all organisations, especially large, older companies with a longstanding hierarchy.

Some organisations may simply choose to make their existing structure a little bit flatter. This involves minimising chains of command and specific orders of communication so interaction is much less defined by position and hierarchical structure within the company. Decision making will become more collaborative and there will be fewer barriers between the top management teams and the employees at the bottom. Other organisations may choose to implement a ‘flatarchy’, remaining a relatively flat company but forming ad hoc hierarchies that are only valid for the duration of the time it takes to work on a specific project or fulfil a particular function.

Anyone and everyone will have the power to become a leader

In line with the disappearance of formally designated leaders, employees will no longer have to obtain an official position to be considered a leader within the organisation. Collaboration platforms allow any employee to become a leader if their ideas gain traction on such platforms. Just as online personalities have built followings on social media platforms, such as blogs, YouTube and Facebook, and have become authorities of sorts, employees can do the same within their organisations. If your peers and co-workers understand, respect and follow you and the content you are creating on company communication platforms, there is no reason you need to wait until you are formally designated as a leader of creative projects within the organisation. However, even after you become an effective leader for a certain project, you may not rely on traditional chains of command. The only way to organise, utilise and develop human talent will be voluntary collaborations driven by active communication.

Whether employees are assigned to projects by their companies, cherry-pick which projects to devote their time to in a modular organisation or organise and recruit talent for projects of their own, collaboration will be a fundamental part of this new chapter in modern corporate history. Through this change, employees may obtain a greater sense of fulfilment and overcome the limitations of the Peter principle, which posits that employees in a hierarchy are promoted to the level of their incompetence or until they lack the abilities to excel in the position enough to be passed onto the next step of the corporate ladder.

As there will be so many on-going projects, workers will be able to work on the issues that they truly care about. Due to the brief, temporary nature of these projects, workers will be able to explore a diverse range of projects within their focus area. They will be able to develop the specific skills they wish to develop and progress through a career path they set out for themselves, instead of following a predetermined one. This type of career development will also not be limited to only one company, as most people will work on short-term arrangements across multiple companies.

Working conditions will become much more flexible and customisable

Flexible work hours and days

The traditional 9-to-5 workday made sense when the only way a manager could monitor their employees' work behaviour was physical observation within the office space. Now, employees and managers no longer have to be physically in the same workspace. With online messaging, open collaborative platforms, virtual work environments and video conferencing, employees can communicate and work with their peers and managers anytime, anywhere. More and more companies are allowing employees to work whenever and wherever they can be most productive, which, for a substantial portion of the workforce, is not between the hours of 9 a.m. and 5 p.m. anyway. Workers are no longer obligated to wake up early in the morning, endure morning traffic to get to work by 9 a.m. and suffer through rush hour traffic at 5 p.m. Employees are afforded greater control over their work schedules, resulting in more satisfaction and fulfilment. In turn, this can strengthen employee's commitment to their work and result in higher-quality contributions.

It is critical that companies begin offering more flexible work schedules, as it is one of the most important factors employees consider when venturing into entrepreneurship or considering working for a company. Workers who perform independent work, both on the side and as their main form of income, cite the ability to enjoy more flexibility and autonomy as one of the top reasons they wish to continue performing independent work (Manyika et al., 2016). In addition, 45% of working adults would be willing to take an approximate 9% pay cut in exchange for a more flexible work schedule (Tahmincioglu, 2016). Seventy-three per cent perceive flexibility as one of the most important factors when considering looking for a job or deciding what company they should work for. In a single year alone, Deloitte said it saved $41.5 million in turnover costs by providing flexible arrangements and retaining employees who said they would have left the firm had they not been afforded such flexibility (Richman et al., 2011).

Remote work

Companies will allow employees to work in the environment they feel most productive, although this does not mean wholly eliminating face-to-face meetings or any time in the office. However, there must be an efficient system with clear guidelines so employees do not get side tracked and still fulfil their obligations to their employers, whatever they may be. For example, Schneider Electric has three individual mobility profiles for employees: Resident, for employees who work at the office for more than 65% of all working hours; Flexible, for employees who work at the office 30% to 65% of the time; and Nomad, for employees who work at the office less than 30% of the time (Jacob, 2014). Employees are free to choose the profile that optimises their productivity. Unilever follows a similar approach through what it calls ‘agile working’, allowing employees to work anywhere and anytime, just as long as they fulfil their goals and obligations (Jacob, 2014). One may assume flexible working conditions are only a strong draw for young prospective employees, but research shows that workers all across the spectrum consider it important enough to sacrifice other aspects of their work for greater flexibility.

Such new digital technologies will require both managers and employees to redraw the boundaries between work and life. Everyone will be easily reached – and monitored – at all hours of the day. However, technological preferences may vary vastly from individual to individual. Some may relish the newfound possibility to know what co-workers are doing at all times and to be able to share ideas, comments and updates instantly as they arise. Others may still value a sense of separation from work, preferring to interact and communicate during an allotted time of the day, even if it is not the typical 9-to-5 workday. Differences in such digital habits may lead to misunderstandings, unnecessary tension and arguments. For example, one employee may have no qualms about sending work-related emails at any point in the day, but some recipients may feel annoyed about being contacted outside of working hours or feel pressured to respond immediately even when the workday has ended. In addition, workers should be careful not to appear too invasive – for example, monitoring every action a co-worker makes and punishing every mistake. Everyone must be vocal about their preferences and accepting of others’ habits. However, employees with compatible digital work preferences ideally should be grouped together for projects or teams. In any case, employees and managers alike must be proactive in creating new workplace norms to maintain respectful, cordial and productive environments.

Alternative forms of compensation will emerge and cause-driven work will become more commonplace

An alternative means of compensation: universal basic income

As so many workers will be displaced with no guarantee of re-employment, many prominent leaders have suggested that governments provide all citizens a small sum called universal basic income (UBI). Deployed to everyone regardless of employment or socioeconomic status, this small sum will enable everyone to survive, maintain a decent quality of life and sustain the reproductive function of family. In addition, UBI would ensure that even those who suffer the negative economic effects of digital automation still have sufficient purchasing power and maintain a stable level of aggregate demand in society (Pulkka, 2017). In addition, with decreasing employment at companies and increasing participation in the platform economy, entrepreneurial ventures, on-demand contracts and other forms of work, UBI will, in a sense, compensate for workers' loss of social benefits from employers, such as health insurance and retirement savings, and resources, such as formal professional training (OECD, 2016). Furthermore, if the transition into the Fourth Industrial Revolution is not as smooth as we hope, it may result in mass unemployment, intense competition for remaining jobs, stagnating economies, social disorder and a slew of other societal ills.

Although numerous countries have already experimented with or are currently in talks to experiment with UBI, the concept is not without criticism, about both its efficacy and the specifics of its implementation. Some critics worry that UBI would discourage people from working and that they would simply live off of the sum they are provided. However, it is unlikely that this sum would be substantial enough that people would be able to live comfortably off of UBI alone (Freedman, 2016). Instead, UBI would probably supplement income and give those at the bottom of the corporate ladder a chance to look for more meaningful or profitable work, rather than toiling away at the lowest-paying jobs. David Grusky, sociology professor and director of the Center on Poverty and Inequality at Stanford University, said the ideal outcome would be for recipients to put the money towards training for higher-skilled, higher-paying jobs – an opportunity only available to the rich.

Another concern is the sum itself. There are proponents for both a partial basic income and a full basic income, with the partial model providing a small sum that does not meaningfully increase the level of social security benefits and the full model replacing and even possible increasing the most basic security benefits (Pulkka, 2017). In either case, the government would have to procure the funds to pay everyone. An oft-cited solution is to tax the business on the massive profits it would earn from automating much of its workforce. In addition to increased productivity and fewer employees on payroll, businesses would profit from substantially reduced overhead costs, as robots do not demand pensions, paid vacations, maternity leaves, employee insurance, overtime compensation or any of the other benefits human employees desire. A recent poll shows that 48% of Americans consider UBI as an appropriate solution to potential worker displacement and that most would not be willing to pay additional taxes – they would expect the business to be taxed (Winick, 2018).

From determining the tax rate for corporations and the sum that should be doled out to displaced workers to gauging the social and political impacts, UBI is a thoroughly complicated subject. Wealth distribution is always a tricky subject and one that high-powered CEOs, many of which probably lead the firms that would benefit most from automation, often painstakingly avoid. Other leaders, such as Bill Gates, have even suggested taxing the robot replacements themselves, but aside from deciding how much to tax the robots – if a robot takes the jobs of five people, the question would surround whether it should be taxed the salary of five people – it is an idea that would take (Delaney, 2017). Although it is certain that social welfare must be re-evaluated along with business practices, much more work must be done – and more workers devoted to the cause – to devise a viable solution, whether it be a well-designed UBI or a completely different initiative.

Working for a cause

Perhaps for the first time since the Industrial Revolution in the late 1700s, we no longer have to work in repetitive, uninspiring jobs. This may usher in an exciting new era in which work is not a stagnant means of earning a living, but a stimulating, constantly changing venture deeply connected to people's individual sense of purpose. People would look to derive more value from a job than just a paycheque, especially as governments may begin providing UBI or other similar mechanisms that fulfil basic economic needs. Workers would be much less motivated by salaries and instead seek the sense of fulfilment that comes from working towards a cause they believe in, under digitally savvy, charismatic visionaries, or with a group of people they have recruited themselves. Such collaborations would create value in society and monetary benefit would be perceived as a part of the overall value created, rather than as the primary motivator in pursuing projects.

Accordingly, some social enterprises have created products using up-to-date technology that aims to create social benefit, rather than commercial profit. For example, the Korean start-up Dot has created the world's first braille smartwatch for the visually impaired called Dot Watch. Although braille products are usually expensive, Dot is working to make the watches as affordable as possible. The Korean government selected the Dot Watch as an assistance device, allowing the company to sell the watch in Korea for just $60, rather than $320 in the international market (Ramirez, 2017). Dot has also donated proceeds of its sales to support a variety of causes related to the deaf and blind, such as translating new content into braille books. 'We just focus on creating the world that we want to see. It's not a business approach,' said Kim, Dot cofounder and CEO, of his venture.

With the rise of communication platforms and crowd sourcing, there has also been an increase in the grassroots information archives started and compiled by citizens, although these would yield no direct economic benefit. In California, residents are detecting earthquakes using a distributed network of sensors and, in Japan, a crowd-based sensing system is being used to monitor nuclear radiation (Hyacinth, 2017). Such community efforts hint that the boundary between work and life may be blurring. With work more tailored to their interests, flexible work schedules, inspiring leaders and unparalleled autonomy, work may become an enjoyable part of people's lives, an extension of their values.

Broader Cultural Implications of Digital Automation and Recommendations for the Future

There are contrasting attitudes towards automation. Opinions tend to be split according to the extent of government support geared towards redeploying those who lose their jobs due to digital automation. Even outside of work, disruptions to personal privacy and democratic principles may give rise to even more existential instability. Nevertheless, there are ways to navigate the colossal wave of change rapidly approaching humanity in the near future. This chapter is concluded with some recommendations for managers and employees.

Recommendations for managers

Managers must be proactive, not reactive

If you start tomorrow, it is already too late. The Fourth Industrial Revolution is progressing at an exponential pace. It is fundamentally different from past revolutions and whether we are able to fend off its effects indefinitely remains to be seen. Only those who are constantly thinking of the future while staying abreast of the challenges of today – a daunting endeavour in itself – will be successful.

Recruit, train and retain those who are creative, empathetic, astute and collaborative

Although digital technologies will continue to dominate more and more areas of both our workplaces and lives, the focus should still be on people. To be able to respond to the speed at which increasingly complex challenges arise, companies will have to be equipped with stellar teams that can devise innovative solutions. Digital transformation will require the strategic alignment of all capabilities across the entire organisation. Human employees with creative, empathetic and social talents will be needed more than ever.

Beware of becoming 'Big Brother'

Certainly, AI has the benefits of collecting and processing amounts of data unimaginable by humans, making very few mistakes, being tireless and being immune to emotional weaknesses. However, these can also become the greatest pitfalls of AI and lead to an eerie surveillance environment, such as that in George Orwell's dystopia *1984*. Amidst robot colleagues, one's humanity can be an invaluable asset, when maintaining cordial, productive bonds between employees would be exponentially more difficult. One should not monitor one's employees' every action or punish them for every mistake. Compassion can go a long way in an environment crowded with logic-driven bots. The same holds for customers, who will want personalised, all-around the clock service, but not a service that feels invasive or emotionless. One must be cognisant that many customers are still wary of so much personal data being public.

Provide fun – empower your staff to partake in creative innovation

It is a period of constant and perhaps never-ending transition. There are so many disruptions occurring – the loss of co-workers, the changed nature of their jobs and robot bosses – that even the employees who survive the digital transformation may feel vulnerable and uncertain. Create a positive environment for employees to view these changes as exciting opportunities that can unleash their potential in ways previously unimaginable. A leader of this era must be able to instil in his employees a sense of creative purpose and motivation.

Redefine the company mission periodically

The only constant in the upcoming age is change. To survive in such an environment, companies must make constant course-correcting changes to make sure they are providing exactly what the customers want and need and not lagging behind. It may be a new norm for businesses to redefine their missions and core values every year or even every quarter.

Recommendations for employees

Enjoy creativity rather than compensation

The Fourth Industrial Revolution will bring its fair share of challenges, but it will also bring boundless creative opportunity for those who are prepared. To stay abreast of the constant change, employees will have to constantly think of the needs and expectations of tomorrow. Regardless of their specialty and occupation, their work lives will be far from repetitive and uninspiring.

Enjoy transitions rather than stability

Employees will have to abandon the idea of having a steady career path that they can cruise through. They will have to take control of the situation and enjoy these changes and the boundless opportunities to continue to challenge and reinvent themselves. The more transitions one creates or experiences, the more value one may add to one's future career path.

Transform yourself from contract employee to creative contract developer

Just as employees will no longer be confined within a set career path or a given organisation, they will no longer be beholden to their employers. They should explore the outer reaches of their potential by organising and seeking projects that are tailored to their interests as individual human beings, not as employees to create commercial value.

Be proactive and social associates

The new business environment will necessitate everyone to carve out their own paths and seek out their own value. They should share ideas, collaborate and build meaningful relationships to build a stable foundation for themselves even in the midst of rapidly changing work teams. To initiate one's own meaningful projects, one will require strong social power to attract colleagues and partners.

Rethink your work-life balance

Work will no longer take place in a 9-to-5 mould or in the traditional 5-day workweek. Be it remotely or at hours of the day during which one is most productive, companies – if one chooses to stay with one – will develop increasingly flexible work arrangements that allow employees to work wherever and whenever they choose, often with whoever they choose to work with. Work will no longer simply be a means to obtain a paycheque, but may transform into a medium that allows individuals to define the real meaning of their lives.

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CHAPTER 5

Automation and the Future of Work in Developing Countries

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Automation and the Future of Work in Developing Countries

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Introduction

When Travis Kalanick and Garrett Camp, co-founders of Uber, first came up with the idea of developing their highly successful ride-sharing app, their inspiration came from Camp's experience of having to pay US$800 to hire a private chauffeur one New Year's Eve in Silicon Valley, California (Shontell, 2014). The two began to think of ways to reduce the cost of hiring premium black car services. One of those ideas was to share the car service with several clients who did not necessarily need to use the car during the entire time for which it was hired. In such an arrangement, the car service could be used by another client while waiting to be called by the other. Kalanick floated the idea of developing an app that would allow just that. A beta version of the app went on-line in 2010 and was officially launched soon after in San Francisco. By the following year, Uber had launched in New York City, Chicago and Paris.

Today, Uber is available in over 630 cities worldwide and has become the posterchild of both the 'shared economy' and the 'gig economy' – two disruptive phenomena that have changed the system of resource allocation and the nature of jobs in many sectors. Although the basic on-line platform and ride-sharing service is standard across all locations, the nature and magnitude of impact on each local transportation sector varies. In rich US cities where 9 out of 10 drivers cite 'being their own boss' as their primary reason for joining (Hall & Krueger, 2017), most drivers are part-time or 'gig' workers who use their own cars and drive for Uber to supplement their other sources of income. They are more similar in terms of age and educational background to the general American workforce than to taxi drivers and chauffeurs. Their passengers tend to be relatively affluent and although most passengers do not use ride-hailing apps on a regular basis as most of them own personal vehicles, those who do use ride-hailing apps regularly also use other forms of transportation regularly, including public transport (Pew Research Center, 2015).

This story is a familiar one whenever the benefits of today's shared economy are discussed. Idle or underemployed resources are put to greater use, shared use brings cost per user down and preferences shift towards mutualised access takes rather than individual ownership.

It is a different story in Manila, the busy Philippine capital with a population of over 10 million people, where commuters spend hours on the road each day due to heavy traffic congestion. Rather than a reduction in car ownership, local auto sales particularly in the sub-compact category, have been notably boosted by the rise in popularity of Uber and its former major Southeast Asian rival, GrabCar, which absorbed Uber's operations in the region in March 2018. A small survey by the University of the Philippines estimates that 70% of Uber and GrabCar partners bought brand-new cars specifically to put into service (Paronda, Regidor & Gaabucayan-Napalang, 2017). Many entrepreneurial Filipinos have taken the rise of ride-hailing apps as an opportunity to enter the local transportation business with minimal bureaucratic hurdles from government. Small fleets of vehicles are operated as small businesses, similar to a taxi company, but with the efficiency-enhancing technology of the mobile platform. Many drivers do not own their vehicles and instead work for a 'partner operator' who owns the vehicle and with whom they enter into a profit-sharing agreement. Uber actually set up a service to match these drivers with preapproved operator-owned vehicles. Rather than seeing it as a gig, these drivers depend on the job as their primary source of income and the entrepreneurs who set up these fleets operate them as full-fledged businesses. Meanwhile, passengers have become increasingly dependent on Uber and GrabCar given the lack of tenable alternatives as metropolitan Manila's poor public transport systems, unreliable mass transit and limited walkability leave commuters with few options. Thus, although ride-hailing apps may present an interesting case study for digital innovation in the US, they offer a far more complex case study for economic development in the Philippines.

When futurists speak of automation, artificial intelligence, machine learning, 3D printing and big data analytics, context tends to be overlooked. However, as the stories of Uber and GrabCar in America and the Philippines demonstrate, the impact of new technology can differ widely across the specific contexts in which they are introduced. In both countries, digital technologies that enable 'uberisation' have boosted productivity and improved consumer welfare, but the effects on resource allocation, labour employment and consumer behaviour have not been the same. Thus, the appropriate response in terms of regulatory action, government policy and institutional support may be very different.

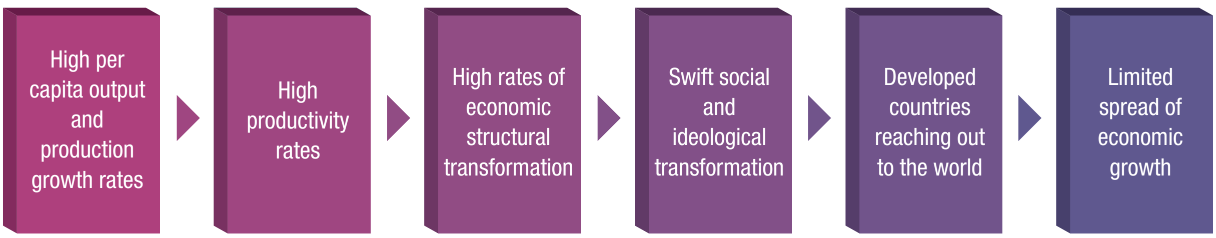
The value and impact of technological improvement depend on social, economic, political, cultural, geographical and historical context. Depending on context, technologies can produce results that are desirable or undesirable, permanent or temporary and effective or ineffective. Therefore, it is important to understand how the possible impacts of automation on education and the nature of work differ between developed and developing countries.

Structural Transformation and Differences in Fundamentals

The impact of automation on jobs depends on the types of jobs that exist. In turn, the types of jobs that are available in an economy depend on the nature of economic activity and the relative importance of different sectors that make up such economy – in other words, a country's level of economic development. In general, as a country's economy develops, resources shift from low-productivity traditional sectors, such as agriculture, to more productive modern sectors, such as manufacturing and services, in a process called 'structural transformation' (Kuznets, 1971). This transformation is essential to development, as capital accumulation, technological innovation and productivity growth tend to concentrate in the modern sectors, whereas the traditional sectors remain technologically backwards and economically stagnant.

In his pioneering work, Kuznets found that all developed countries followed the same process of structural transformation on their path to development (Figure 1). Since then, the commonly recognised developmental challenge has therefore been how to ensure that resources flow rapidly to the modern sectors. Policymakers have scrambled to liberalise markets, encourage greater competition and foster macroeconomic stability to facilitate this transformation in what has quickly become a notoriously 'one size fits all' approach to development. Many governments have responded to the development challenge under the assumption that policies that work in one country can work in any other.

Figure 1: Kuznets' structural transformation model

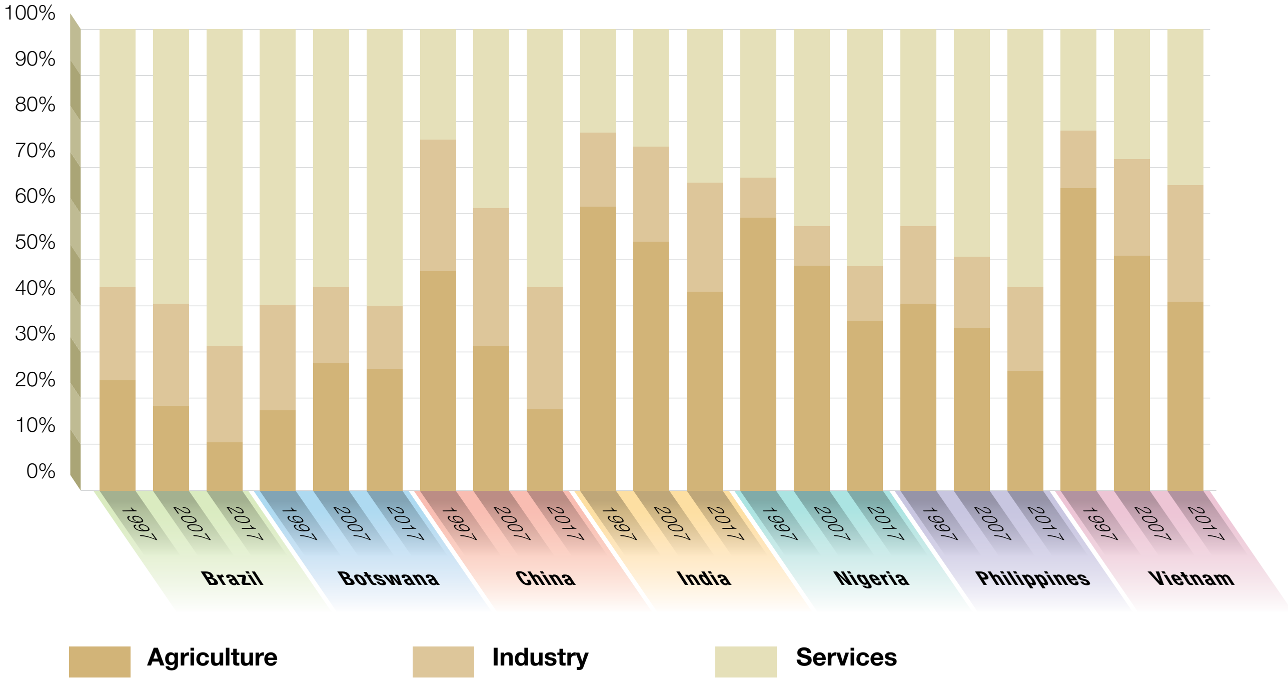


Source: Adapted from Kuznets, Simon, 1971. Simon Kuznets – Prize Lecture. In Nobel Lectures, Economics 1969-1980, Lindbeck, A. (Ed.), 1992. Singapore: World Scientific Publishing Co.

However, the more recent history of developing countries in Asia, Latin America and Africa show some divergence in their development paths (Figure 2). Some countries, such as Vietnam, have demonstrated the expected pattern of resource reallocation from low-productivity agriculture to export-driven manufacturing. However, other countries, such as Brazil and the Philippines, have seen a less rapid decline in the employment share of agriculture, with no accompanying boom in manufacturing. In India, the expansion of finance, information technology (IT) and business process outsourcing (BPO) has contributed significantly to a rise in the employment share of services. Meanwhile, there have been countries, such as Botswana, that have effectively seen no structural change in the past two decades.

Why have some developing countries followed the expected process and most others have not? Specific social, economic, political, cultural and technological contexts, including a country's current stage of development, determine the results of its structural transformation and the rate at which economic growth occurs. In small countries that have become globalised, international trade accelerated structural transformation (Święcki, 2017, pp. 95-131), as demonstrated by the case of South Korea. Government policies may also have had distortionary effects. For example, in China, impediments to labour mobility, particularly the Hukou household registration system, which restricted access to public services, such as education, health, housing and pensions based on place of birth, slowed the movement out of agriculture (Dekle & Vandenbroucke, 2012, pp. 119-135) even as manufacturing in the urban sector grew. In Brazil, import-substitution policies aimed at protecting local companies from foreign competition did not help boost productivity growth, but might have actually hurt the economy by removing incentives to improve efficiency to remain globally competitive (Gonzaga, Menezes-Filho & Terra, 2006, pp. 345-367). In many African countries, such as Ghana, heavy dependence on natural resources and minerals created a strong bias towards resource-based, extractive industries, slowing down the rate of structural transformation. In countries, such as Nigeria, poor infrastructure and inadequate human capital have continued to be major obstacles to meaningful transformation.

Figure 2: Share in total employment of each sector in selected developing countries



Source: World Bank, 2018. World Bank Open Data. Available at: https://data.worldbank.org/

Differences in the speed and nature of structural transformation observed among developing countries seem to be largely explained by differences in context. Thus, context once again becomes key to understanding differences in outcomes. In this case, context can be broadly defined by what economists call ‘fundamentals’ (McMillan, Rodrik & Sepulveda, 2016). These fundamentals include the quality of institutions (governance, rule of law and business environment), the state of infrastructure development (physical and social) and the level of human capital (education, skills and training).

Good institutions encourage capital accumulation and reduction in transaction costs. Businesses thrive and investments flourish when property rights are protected, contracts are enforced and public services are adequately provided. Citizens engage in productive economic activities and long-term commitments, such as education and skills development, when the business environment is stable and predictable. In contrast, weak institutions discourage investments in capacity building and R&D, locking resources in low-productivity sectors and activities (Aron, 2000, pp. 99-135). Infrastructure development is equally important as a facilitator of structural transformation. Unless the necessary investments are made in infrastructure, both physical (roads, bridges and ports) and social (education, healthcare and social protection), modern sectors of manufacturing and higher-value services could not develop to their full potential.

Finally, as an economy transforms, its workforce moves from labour-intensive occupations to skill-intensive ones. Although this movement is facilitated by well-functioning institutions and supporting infrastructure, it is largely dependent on how quickly and effectively the workforce can acquire the necessary skills and competencies required by the jobs in the new sectors. Unless workers are equipped with the necessary skills and human capital to gain employment in the modern sectors, the productivity gap is meaningless and does not become a driver of structural transformation or sustainable economic growth.

The Impact of New Technology on Developing Countries

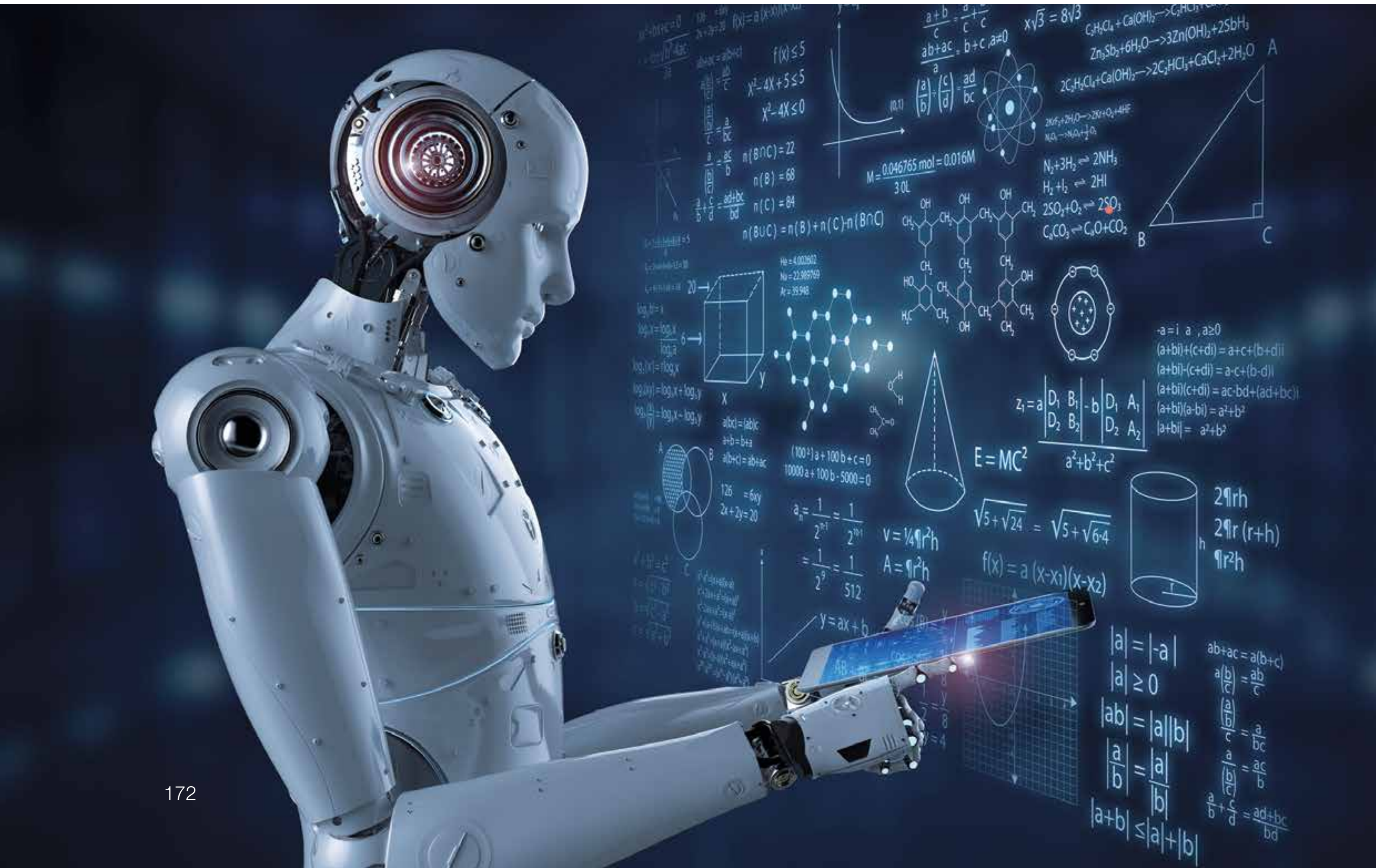
The patterns observed in the structural transformation of developing countries provide clues on how the introduction of new technologies may impact economies during the Fourth Industrial Revolution. Structural transformation is primarily driven by technological change that is biased towards a particular sector or activity. Increased productivity in the technology-enhanced sector drives resource reallocation towards it. Therefore, as the new digital technologies of AI, machine learning, automation, robotics and big data analytics enhance existing sectors and possibly allow the formation of new ones, it will be interesting to see how these new technological will change the structure of developing economies.

Technological progress at the national level can occur either through the invention and innovation of new technologies or the adoption of 'imported' technologies and through its eventual spread across firms and individuals in the economy. Most technological progress in developing countries comes from the adoption or adaptation of pre-existing technologies borrowed from developed countries (World Bank, 2008). Currently, the pace at which technology spreads between countries is accelerating so that the technology gap between middle- and high-income countries has narrowed significantly. Whereas new technology in the 1800s took as long as 100 years to reach 80% of the world's countries, for a new technology to reach 80% of the world's countries today it takes less than 20 years (World Bank, 2008).

The rate at which new technologies are adopted by firms and individuals has also generally increased over time. Whereas electricity and telephones took approximately 30 years to become widely used, mobile phones and the Internet have taken less than 10 years (Williamson, Raghnaill, Douglas & Sanchez, 2015). Alongside the differences in the nature of these technologies, differences in context, particularly in the regulatory and business environments in which they were introduced, partly explain this acceleration in the rate of technological diffusion. Many old technologies, such as electricity, fixed-line telephone systems, sanitation and railroads, were either provided by government or operated under heavy regulation, which subjected them to public sector constraints or government failure. In contrast, many new technologies, such as mobile phones, the Internet and computers, are being delivered in business environments that harness private capital and often encourage greater competition. The market structure in which tomorrow's digital technologies will be introduced in developing countries will be a major factor in determining its impact. Developing economies that are open and liberalised are likely to converge quickly with developed ones in terms of access to these new technologies.

In general, technological advancements are good for developing economies, especially in the long run. New technologies improve labour productivity, lower the cost of production and improve product quality. They also allow greater market access and increase economies of scale. Most importantly, they allow the economy to shift to activities that produce greater value. What worries many policymakers and business leaders is how these technologies will impact the nature of jobs, the patterns of employment and, ultimately, the sources of competitive advantage in the short to medium term. New technologies, after all, can be highly disruptive.

There is a common fear of 'radical' technologies. However, most forms of new technology develop gradually or incrementally in a process of 'parts-assembly', whereby existing technological components are combined in new ways. When technologies gradually evolve to a point at which radical socioeconomic impacts do arise, then disruption occurs. However, the disruptiveness of a technology is not intrinsic to the technology itself. Rather, it is a function of the environment that the technology is disrupting. When McKinsey touted mobile Internet, the automation of knowledge work, the Internet of Things, cloud technology, advanced robotics and self-driving cars as the most 'disruptive technologies…that will transform life, business, and the global economy' (Manyika, Chui, Bughin, Dobbs, Bisson & Marrs, 2013) in 2013, pundits scrambled to make sense of the impact that each technology would have on the economy. Today, Uber and similar ride-hailing apps demonstrate clearly how the combination of these technologies can impact jobs, markets and daily life.



Learning from the Impacts of the Digital Revolution

Whether or not a new technology would be disruptive is uncertain and difficult to predict, as the long-term impact of new technology depends on the specific context, time and place in which it is introduced. However, there are general patterns of change that may be observed from the past that can provide guidance for the future.

Past experience has shown that existing jobs may be destroyed, as technological advancement increases productivity, thus requiring less input for the same output. Some jobs and economic activities may become obsolete or unnecessary due to changing processes and preferences. However, new jobs may also be created that (1) support and expand the new technology or (2) use the new technology to produce existing products or new ones.

The recent 'Digital Revolution' provides insights on what the impact of technological change may be and how to prepare for it. Technological advancements in information and communications technology (ICT) have marked the so-called Third Industrial Revolution, ushering the way to the Fourth Industrial Revolution, whereby emerging technological breakthroughs in automation and artificial intelligence are expected to multiply the possibilities introduced by digital technology.

ICT encompasses a wide range of products, both goods and services, that are primarily intended to enable or fulfil information processing and communication by electronic means (OECD, 2009). The ICT sector includes the manufacturing industries for equipment, such as computers and peripherals, mobile phones and other consumer electronics, and software and licensing services. It also includes IT consulting services and telecommunication services, which is the backbone of the ICT sector.

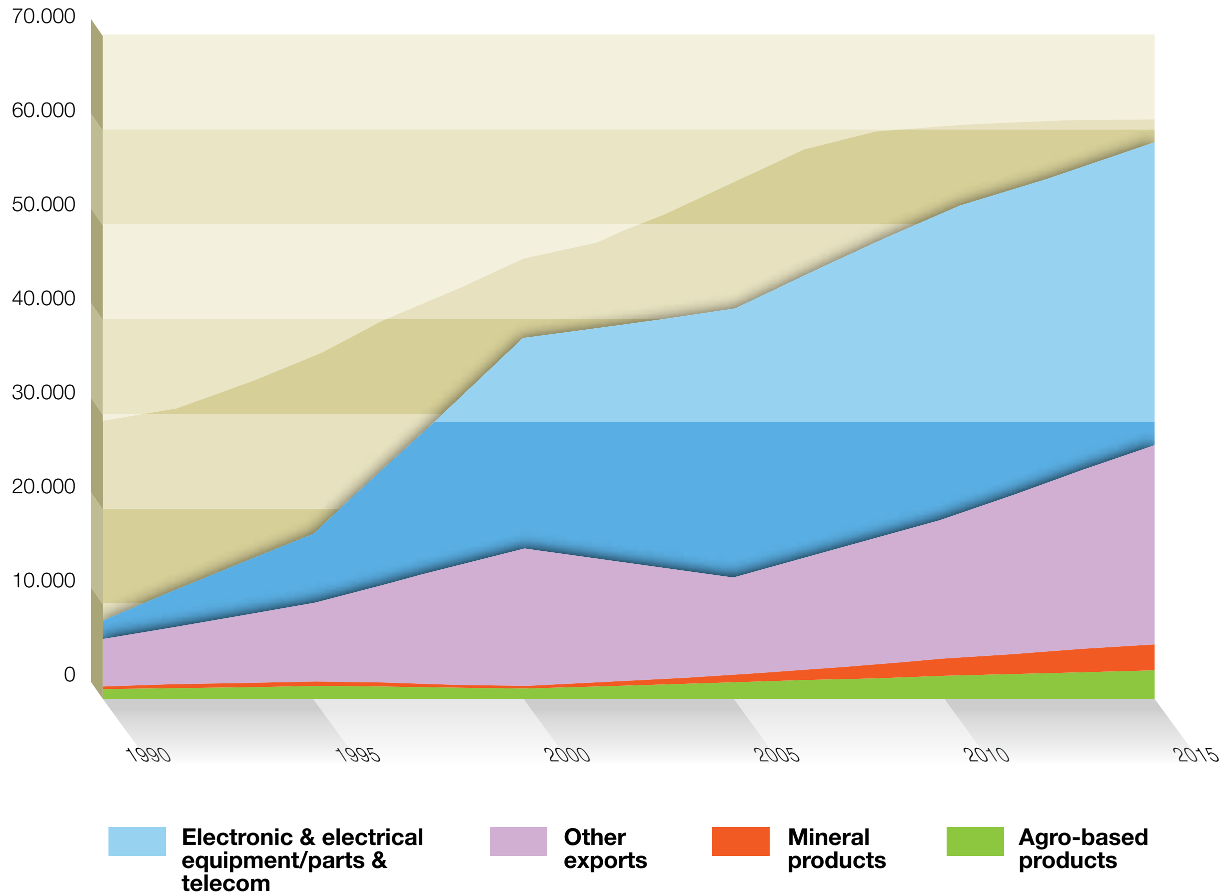
Advancements in ICT have benefitted economies through direct investments in the ICT sector itself and through technological improvements that have led to productivity gains in ICT-using sectors (UNCTAD, 2011). New 'digital jobs' have been created in both the ICT or 'ICT-enabling' sectors that produce, support and expand ICT products and in 'ICT-enabled' sectors that make use of digital tools. However, the macroeconomic impacts of ICT over the last three decades may not have been the same for developing countries as for developed ones. On paper, the use and economic applications of ICT, more than the production of ICT, were expected to make a powerful contribution to economic development. However, a comprehensive study by UNCTAD found that although productivity gains in developed countries indeed came mainly through the use of ICT in various sectors, in developing countries productivity gains came mainly from the ICT sector itself (UNCTAD, 2007). Other studies show that although developed countries experienced substantial gains and achieved an increase in their output through the use of ICT, developing countries did not benefit as much due to the lack of infrastructure investment (Dewan & Kraemer, 2000, pp. 548-562; Yousefi, 2011, pp. 581-596). Only once a critical mass of ICT infrastructure was reached did it begin to show a positive relationship with economic growth (Roller & Waverman, 2001, pp. 909-923).

Different forms of ICT have had different macroeconomic impacts, depending on the level of development of a country. In developed countries, what were then considered as more advanced ICTs, such as broadband Internet, generally had greater economic impact than simpler technologies (UNCTAD, 2011). In less developed countries, where broadband infrastructure was very limited, mobile phones and radios had more significant impact. Mobile phone proliferation, in particular, was found to have a very strong positive impact, especially in rural areas where the older landline technology was not extensively available. Furthermore, unlike more advanced ICTs, such as computers and broadband Internet, mobile phones did not require higher levels of education or income.

The impact on employment was also different for less versus more developed countries. Most of the new jobs generated in poorer countries came from the telecommunications sector, rather than the ICT sector itself, as adequate telecommunications infrastructure was a prerequisite for ICT development. However, some middle-income countries, including many in Southeast Asia, experienced a boom in the ICT export manufacturing sector. For example, in the Philippines, a major shift in the composition of exports occurred in the 1990s, as semiconductors, computer parts and electronics, replaced timber and agricultural products as the country's biggest exports, reaching a peak of over 70% of export earnings (Figure 3). Today, the electronics industry accounts for over 50% of Philippine exports in terms of value and approximately 500,000 jobs.

Although this experience was certainly not the same for all developing countries, many of the country's peers in the region, such as Malaysia, experienced the same pattern of growth in electronics exports. The growth of these industries coincided with globalisation and the rise of global production networks, whereby labour-intensive segments of technologically complex production are separated from the capital- and skill-intensive segments and are relocated in developing countries to take advantage of cheaper labour costs. Thus, most of the jobs created were in labour-intensive assembly and product testing. For such purposes, the Philippines had a clear competitive advantage given its young, well-educated, English-speaking workforce that was highly trainable yet relatively inexpensive. Other factors that contributed to this success were fiscal policy incentives, including tax breaks, and the creation of special export zones to encourage foreign direct investments and adequate infrastructure (e.g. ports, roads and utilities) and logistics.

Figure 3: Value of Philippine exports per commodity group (in US$ million FOB)



Sources: Philippine Statistics Authority, 2001. 2001 Philippine Statistical Yearbook. Available at: https://www.psa.gov.ph/products-and-services/publications/philippine-statistical-yearbook/2001; Philippine Statistics Authority, 2006. 2006 Philippine Statistical Yearbook. Available at: https://www.psa.gov.ph/sites/default/files/2006%20PSY_1.pdf; Philippine Statistics Authority, 2017. 2017 Philippine Statistical Yearbook. Available at: https://www.psa.gov.ph/sites/default/files/PSY_2017_Jan%2016%202018.pdf

A combination of these external factors, intrinsic characteristics and purposive government action resulted in the positive impact that ICT had in the Philippine export sector. A similar combination resulted in the rise of a new sector that has had an even bigger impact on the country's economy, particularly on the IT-BPO industry.

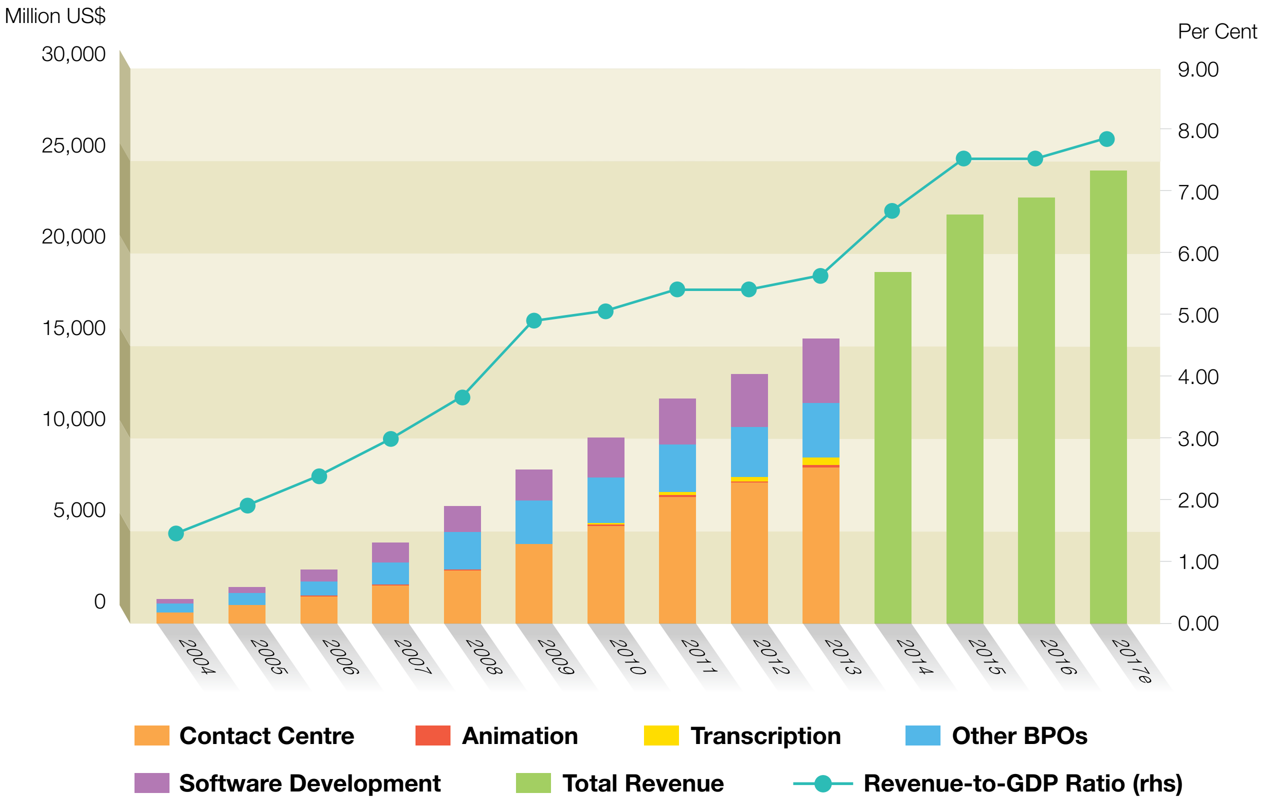
The Rise of the IT-BPO Industry: An Example from the Philippines

Although the rise of the Philippine semiconductor and electronics industry demonstrates how technological advancements benefitted ICT-enabling sectors, the rise of the country's IT-BPO sector demonstrates how technological advancements benefitted ICT-enabled ones.

Advancements in ICT remarkably broadened the possibilities of international trade, making services tradable across national boundaries. As value chains globalised, a wide range of business processes, from low-value to high-value activities, could be produced in different locations around the globe, all connected through ICT. These activities ranged from contact or call centre services, to transcription, animation, software development, backroom operations, data processing and consultancy services. The rise of such BPO allowed many developing countries, including the Philippines, to expand and diversify exports beyond manufactured goods and agricultural commodities. Global trade in services now account for 13% of the world's gross domestic product (GDP) and as much as 46% of total global exports in value-added terms.

The Philippine IT-BPO sector presents a remarkable case study of the macroeconomic impact on jobs, employment, income and investment of ICT advancements in a developing country. From generating revenues of approximately 1% of GDP in the early 2000s, the Philippine IT-BPO industry today earns US$25 billion per year, amounting to approximately 8% of the GDP and employs over a million workers (Figure 4). From 2001 to 2011, the industry grew by 30% annually – faster than the growth rate of the global offshore services market.

Figure 4: IT-BPO revenues per subsector and revenue-to-GDP ratio



Sources: Authors' computations using data from Bangko Sentral ng Pilipinas, 2013. Results of the 2013 Survey of Information Technology-Business Process Outsourcing (IT-BPO) Services. Available at: http://www.bsp.gov.ph/downloads/publications/2013/ICT_2013.pdf;
IT and Business Process Association of the Philippines, 2016. As cited by the National Economic and Development Authority, 'The Philippines' Socio-Economic Performance, Outlook, Challenges, and Vision', PowerPoint Presentation; Oxford Business Group, 2018. Philippines: Year in Review 2017, BusinessWorld Online, 5 January 2018. Available at: http://bworldonline.com/philippines-year-review-2017/;
Philippine Statistics Authority, 2018. Quarterly National Accounts (Q1 1998 – Q1 2018). Available at: https://psa.gov.ph/sites/default/files/1Summary_93SNA_qtr.xls;
World Bank, 2018. World Bank Open Data. Available at: https://data.worldbank.org

The rise of this ICT-enabled sector provided the Philippines an opportunity to establish linkages to global value chains, giving it access to the global market for services and the employment opportunities that came with it. It also helped boost labour productivity, particularly among those employed in the sector. The gross value added[1] of someone employed in the IT-BPO sector is twice that of someone in the services sector in general and up to four times that of someone in tourism or trade[2]. In turn, this translates to higher salaries and more attractive employment benefits for those employed in the sector. The IT-BPO boom has had multiplier effects on the rest of the economy through connections with real estate and construction, as BPO firms gobbled up commercial office space and with retail and personal services as a direct result of higher disposable incomes.

[1] Gross value added is a common measure of productivity. It provides a dollar value for the amount of goods and services produced, less the cost of all of the inputs and raw materials that are directly attributable to that production.
[2] Based on data from the *Bangko Sentral ng Pilipinas* and the Philippine Statistics Authority.

The Philippines IT-BPO sector began in the mid-1990s with a small number of American firms setting up contact centres offering primarily voice services. It grew rapidly in the 2000s and by 2010 the Philippines was the global leader in voice services, second only to India in non-voice services. More recently, the sector branched out into higher value-added services, such as finance and accounting, human resource management, payroll and transcription services, and into knowledge process outsourcing services, such as legal and business consulting.

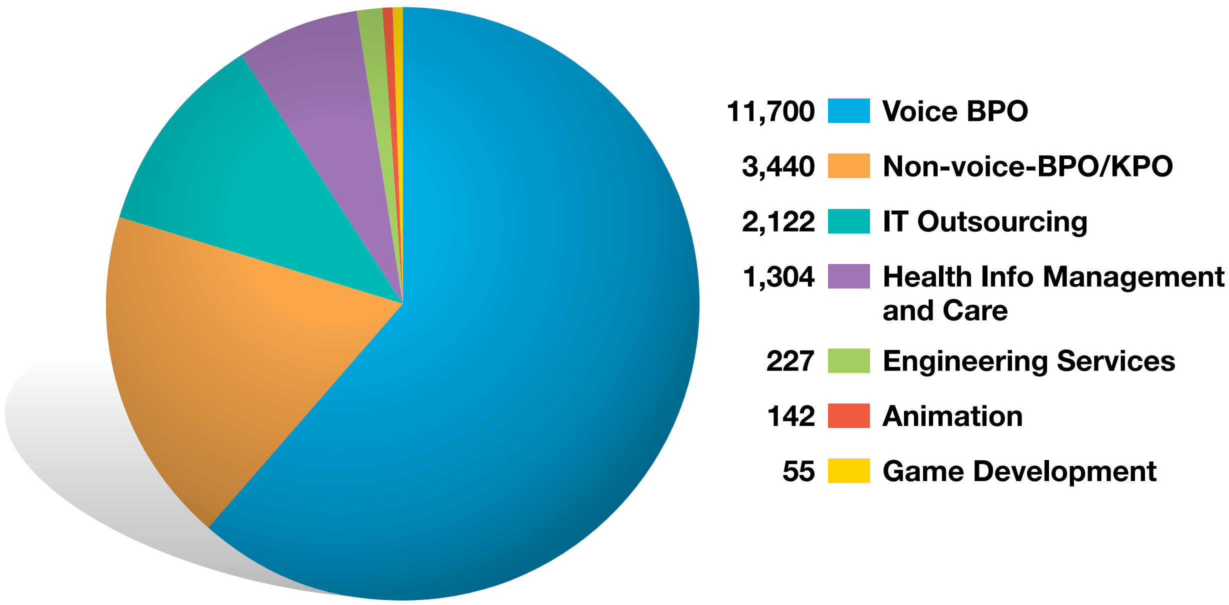
Writing for the World Bank, Mattoo and Wunsch (2004) attributed the successful rise of IT-BPO sectors worldwide to three major factors: (1) advancements in ICT that enabled this global trade in services, (2) substantial investments in education in developing countries amidst limited commensurate employment opportunities resulting in an abundance of skilled labour at relatively low cost and (3) intensified pressure in developed countries to adopt new business models that minimise cost to remain globally competitive. However, although these factors certainly help to explain the rise of IT-BPO in developing countries in general, they do not explain why some countries, namely the Philippines and India, have experienced tremendous success in this sector, whereas so many others have had only relatively little success.

Following Mattoo and Wunsch's (2004) description, the Philippines may appear to have had very strong potential from the onset given its abundant supply of English-speaking college graduates and relatively low compensation costs. However, a closer inspection of the business environment shows that market conditions were less than perfect. Although office space was relatively cheap and readily available from the buoyant real estate market and telecommunications infrastructure was fairly adequate following the liberalisation of the sector in the 1990s, electricity costs were among the highest in the region, the labour market was tight and inflexible and political risks were present. However, a combination of both intrinsic and extraneous factors effectively compensated for these market imperfections.

For one, a fair degree of government incentives and support, such as income tax holidays, duty-free importation of ICT equipment, tax deductibility for training expenses, one-stop services for business registration and relaxed foreign ownership restrictions (Yi, 2012), certainly helped make the country more attractive to foreign investors. Furthermore, local industry associations helped promote investments, establish global networks and connections and encourage continued government support (Del Prado, 2015).

As important as these economic and political factors were, less tangible variables might have also been a source of strong competitive advantage for the Philippines. For example, although there may be a comparative level of English proficiency among Indians, Filipinos have a closer affinity with Western culture (Mitra, 2011), particularly American culture. Filipinos, especially those in urban areas, are exposed from a very young age to American television shows, movies and music, making them very familiar with American idioms and accents. Furthermore, Filipinos have also been described as having a highly 'service-oriented' culture (Yi, 2012). Together, these cultural factors are believed to have been an important source of competitive advantage, particularly in doing customer service work for US companies, which make up the biggest chunk of the global market for outsourcing services. Contact centres make up more than two thirds of the Philippine BPO industry (Figure 5), accounting for 12.6% of the global market for BPO services.

Figure 5: Revenue share of IT-BPO subsectors, 2014 (in US$ million)



Source: Information Technology and Business Process Association Philippines, 2016.

This, of course, does not discount the importance of the high educational backgrounds of Filipino workers in making the local IT-BPO sector globally competitive. More than a quarter of the population holds a college degree and more than half a million students graduate from college each year. Of the 500,000 college students who graduate each year, more than half are specialised in the medical field, particularly nursing, more than 20% in engineering and IT and approximately 20% in business or accounting. It is not surprising that the IT-BPO sector recently began to expand to higher value-added services, such as medical and legal transcription, insurance claims processing, credit underwriting and financial advising, to take advantage of this abundant supply of skilled labour.

The patterns observed in the rise of the Philippine BPO industry demonstrates the crucial role that the political, economic, institutional and socio-cultural contexts play in determining the real impact of new technologies on jobs and the economy. Although exactly the same new ICT technologies also reached the country's regional peers, they did not have similar impacts in terms of reach and scale due to the unique combination of particular traits that only the Philippines had at the time.

The Rising Concern of Job Displacement Due to Automation

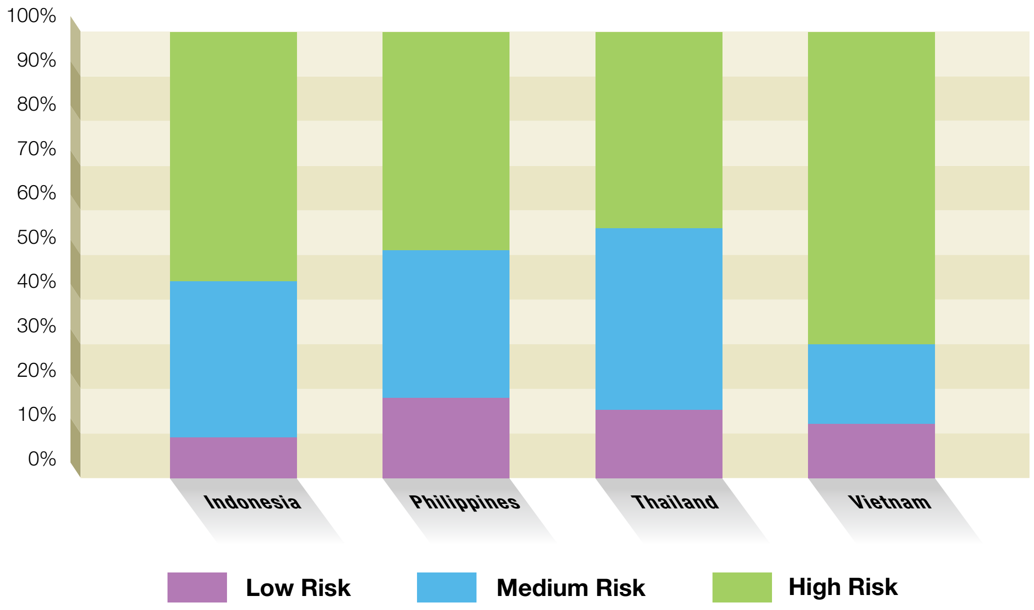
After two decades of seemingly unstoppable growth, the Philippine IPO industry foresees increasing challenges ahead. The local industry association forecasted single-digit growth for the IT business process management (IT-BPM) sector at 9% per annum from 2017 to 2022, which is significantly lower than the 17% annual growth it experienced 6 years before (Information Technology and Business Process Outsourcing Association of the Philippines, 2016). Security issues and political uncertainty, particularly about US trade and investment policy, have been indicated as major reasons for the weaker forecast. However, the threat of automation and AI are increasingly beginning to dampen optimism, even from within the sector.

In 2016, the International Labor Organisation (ILO) warned that as much as 89% of workers in the Philippine BPO sector were at a 'high risk' of automation, as already existing technologies could easily automate IT support, workflow processes and other types of back-office operations. This is certainly alarming for the Philippines, given the country's large dependence on the IT-BPO sector for income growth, dollar inflows and employment. Estimates for the economy as a whole were no less worrisome. The ILO warned that 49% of jobs in the Philippines were at a high risk of automation.

This is of course not a concern exclusive to the Philippines. Developing countries in the region and in the rest of the world also face the challenges of automation. Approximately 44% of jobs in Thailand face a high risk of automation. The numbers are even much higher for Indonesia (56%), Cambodia (57%) and Vietnam (70%), as shown in Figure 34 (Chang & Huynh, 2016).

This ILO report, similar to many others that estimate the impact of automation on jobs, adopted the methodology developed by Carl Frey and Michael Osborne of the University of Oxford (2017, pp. 254-280) to quantify the extent to which jobs could be automated. To classify occupations according to their risk of automation, Frey and Osborne used nine variables to characterise three 'non-automatable' tasks that involved 'perception and manipulation', 'creative intelligence' and 'social intelligence' and then identified the probability of automation for each job in terms of the extent to which the job required these three non-automatable tasks. This automation probabilities were then applied to the national labour surveys of the countries studied.

Figure 6: Distribution of jobs at risk of automation in selected ASEAN countries



Source: Chang, Jae-Hee and Phu Huynh, 2016. ASEAN in Transformation. Available at: http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/publication/wcms_579554.pdf

Differences in the risk of automation across sectors and countries are driven in large part by differences in the structure of the specific industries in each country and the skill level of the jobs in each sector. Jobs at the lower end of the spectrum of skill requirements generally face greater risk of automation. Unsurprisingly, the impact of automation on jobs therefore depends on the specific context in which the automation occurs. For example, the ILO reports that Vietnam, which has the highest share of low-skill jobs among the ASEAN economies studied, faces the highest risk of automation. However, Thailand, which has the lowest share of low-skill jobs, faces the smallest risk of automation.

Following Frey and Osborne's classification system[3], high-skill jobs include managers, professionals, technicians and associate professionals. Medium-skill jobs include clerks, service and sales workers, skilled agricultural and fishery workers, craftsmen and related trade workers, plant and machine operators and assemblers. Finally, low-skill jobs consist of all other 'elementary occupations', including subsistence farmers, market vendors and unskilled construction workers.

The distribution of national employment across sectors with varying skill requirements is an important determinant of the speed and magnitude of the impact of automation on jobs. Countries that largely depend on fewer sectors may be more susceptible to the risk of automation. One example is Cambodia, where over half the labour force is employed in agriculture, construction and garment manufacturing. Based on ILO estimates, nearly half a million sewing machine operators in the country's highly specialised garment industry face an automation risk of almost 90%.

[3] Based on the ILO's 2012 International Standard Classification of Occupations.

The garment industry is especially important in many developing countries, such as Cambodia, Bangladesh and India, where the industry employs millions of low-skilled workers. For the most part, huge differences in the cost of production have driven operations from rich countries, such as the US, where the unit cost of a cotton shirt is approximately US$7, to poorer countries, where the unit cost can go as low as US$0.22 in Bangladesh (Asian Development Bank, 2018). Sewing robots can potentially narrow the cost gap, diminishing the competitive advantage held by labour-abundant developing countries, possibly leading to the ‘reshoring’ of production.

However, the impact of advancements in automation that have been employed in all three countries in the past decade provide a different insight. Previously labour-intensive processes, such as cutting, spreading and ironing, have been automated, requiring one tenth of the workers needed before. Meanwhile, the adoption of Jacquard weaving machines has increased output per worker sixfold. The adoption of these new technologies have increased worker productivity, reducing labour cost per unit, allowing garment producers to expand operations and to take greater advantage of economies of scale, thereby increasing their competitiveness rather than undermining it. Although new technologies displace jobs, they also increase labour productivity. This increases competitiveness, both at the level of the firm and of the industry.

Across developing countries, low productivity is one of the greatest stumbling blocks to income growth and shared prosperity. Workers who are trapped in jobs in less productive sectors face lower wages, harsher working conditions and less favourable employment terms. Structural transformation and shifting employment to more productive sectors certainly improves labour market performance. However, a larger portion of economy-wide productivity growth in Asia has actually come from rapid increases in labour productivity within sectors due to technological change.

Understanding the Complex Relationship Between Automation and Jobs

The International Federation of Robotics defines a machine as an industrial robot if it can be programmed to perform physical, production-related tasks without the need of a human controller. So far the empirical evidence on the impact of industrial robots on employment has been inconclusive. One US study found that from 1990 to 2017, every additional robot displaced six human workers and that increasing robot density by one new robot per thousand human workers reduced workers' wages by half a percentage point (Acemoglu & Restrepo, 2017). In contrast, another study covering 17 developed economies during around the same period found that in industries with high robot densities, robotics accounted for 16% of growth in workers' wages.

Generally, the movement of wages in the long term is supposed to reflect the productivity of labour. Thus, if wages decrease after automation, this could mean that robots have effectively replaced human workers in doing their jobs. However, if wages go up, this may mean that robots have actually helped human workers become better at doing their jobs.

The inconclusiveness of empirical studies highlights the complexity of the relationship between automation and jobs. History proves that new automation technologies have always displaced workers, specifically those directly involved in the function that has been automated. However, both the motivation and the outcome of automation is increased productivity. The net impact that higher productivity has on the macroeconomy tends to be positive, although there are always winners and losers.

Two important concepts must be understood when attempting to predict the impact of automation: (1) the difference between tasks and jobs and (2) the difference between technical feasibility and economic feasibility.

New technologies automate tasks not jobs. A job consists of a bundle of tasks, some of which are more 'automatable' than others. Automation can relieve workers of certain tasks, usually those that are manual and routine, thereby increasing worker productivity and potentially freeing up valuable time and resources for use in more valuable tasks. At first glance, when numerous tasks associated with a particular job are automated, it may be supposed that the worker employed for this job faces a higher risk of displacement. However, more important than the number or volume of automatable tasks associated with a job is the value of these tasks.

For example, a sales clerk in a retail store may have many automatable tasks listed in his job description – obtaining or receiving merchandise, taking inventory, stocking shelves, totalling bills, operating cash registers, accepting payments and making change for customers. Unsurprisingly, shop assistants are among those recognised as facing the most serious threat from automation by the ILO (Chang & Huynh, 2016). The rapid rise and mass adoption of e-commerce and warehouse robots certainly poses a double threat to sales clerks and shop assistants, but as the retail industry absorbs these new technologies, it may gradually begin to realise the full potential of these tools in increasing customer value. The slow but steady rise of hybrid retail models, combining brick-and-mortar presence with extensive use of e-commerce, automation and data analytics, points towards a more sophisticated outcome than a linear prediction of job displacement by automation.

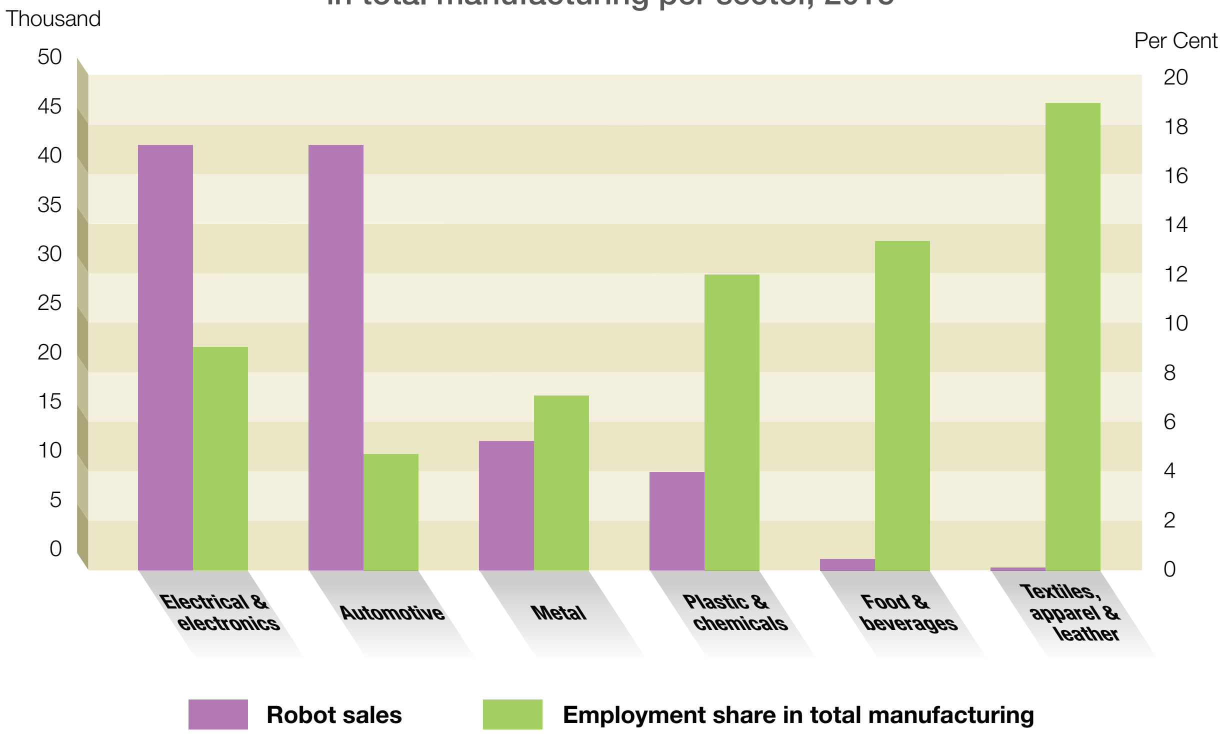
It is at least as likely that the job of the sales clerk or shop assistant can survive this round of automation and evolve into a job that is valued more for tasks that require human interaction – helping customers choose a product, providing feedback to their queries, addressing their concerns or apprehensions and enriching the total customer experience. Although these tasks may represent a smaller number or share in the volume of tasks associated with the job of a sales clerk, the value of these tasks to the customer and ultimately to the business may be greater than those of the tasks that are automatable.

In many countries in developing Asia, the trustworthiness of a salesman may be far more important than the reputation of the brand or the organisation that he represents. A study covering 13 Asian countries and 5 Western countries found that in most Asian countries, including China, India, Japan and the Philippines, people depended more on interpersonal trust towards the other person rather than on institutionalised trust towards the system or organisation (Witt & Redding, 2013, pp. 265-300).

The other important concept to understand is the difference between technical feasibility and economic feasibility. Advancements in technology make the automation of many tasks technically feasible. Sewing robots may technically replace workers in India or Bangladesh. Chatbots that are able to conduct basic conversations with humans may technically replace contact centre agents. However, what is technically feasible is not necessarily economically feasible.

Although the use of robots in Asia has been rapidly increasing, with China, Japan and Korea leading the deployment of close to 890,000 robots as of 2015, most of the robots were deployed in capital-intensive industries, namely electronics, automotive, metals processing, plastics and chemicals. These industries generally do not employ as many human workers as labour-intensive industries (Asian Development Bank, 2018). For example, the automotive industry accounted for almost 40% of robots deployed in Asia, but only provided 4.2% of total employment. The electronics industry accounted for 39% of robot deployment, but only 9.2% of employment. In contrast, the food and beverage industry accounted for only 1.3% of robot deployment, but provided 12.3% of total employment. Meanwhile, the garment, textile and leather industries, which accounted for a mere 0.1% of industrial robots, provided 19.2% of employment (Figure 35). This implies that although automation has certainly begun to take hold in certain industries across developing Asia, its adverse impact on employment may not become as widespread as originally feared, particularly not among those where it is not yet economically feasible.

Figure 7: Robot sales and employment share in total manufacturing per sector, 2015



Source: Asian Development Bank, 2018. Asian Development Outlook 2018: How Technology Affects Jobs. Available at: https://www.adb.org/sites/default/files/publication/411666/ado2018.pdf

The cost of installing, programming, operating and maintaining robots that can technically replace human workers in offshore factories must be low enough to offset the cost savings that initially motivated the offshoring or subcontracting of production. The initial cost of purchasing new technologies will be high, in both explicit and implicit terms. On top of the financial investment needed to make the large capital expenditures involved, companies will have to consider the costs of organisational change. Furthermore, when certain non-automatable tasks continue to be necessary for operations, including cognitive tasks that must carried out alongside those that are automatable, the total cost of operations will have to be considered. Therefore, the decision to automate may not be as straightforward as a simple comparison of per unit costs between robot and human employment would allow.

The question of economic feasibility is further complicated by considering commercial viability in the long run. The decision to automate will be influenced not just by the comparison of current costs, but also the criteria of long-term sustainability and customer value creation. The emergence of new technologies has excited the imaginations of observers picturing a world where robots and computer programs with artificial intelligence replace countless tasks that humans were once employed for. However, as inflated expectations eventually wane, business managers will realise that an optimal mix of automation and human employment will have to be determined based on a criterion that goes beyond myopic cost comparisons.

For the customer who loses his credit card or discovers a suspicious transaction in his monthly statement, the reassurance and peace of mind that comes from speaking with another human who is able to empathise with him is difficult to replace with a chatbot or self-service application, no matter how efficient or foolproof it may be. Some banks that aggressively pursued the adoption of intelligent interactive voice response (IVR) systems for their customer hotlines have begun to rollback after receiving negative feedback from their customers. A key realisation was that although customers may appreciate the ease and efficiency of interacting with a chatbot or IVR system when accessing some basic services, such as balance inquiry, many customers value being able to speak with a human when making more sophisticated requests or inquiries. Some banks have even introduced dedicated hotlines that connect calls directly to customer agents without going through IVR systems as a premium feature of high-end products, revealing that customers have a higher willingness to pay for personal treatment.

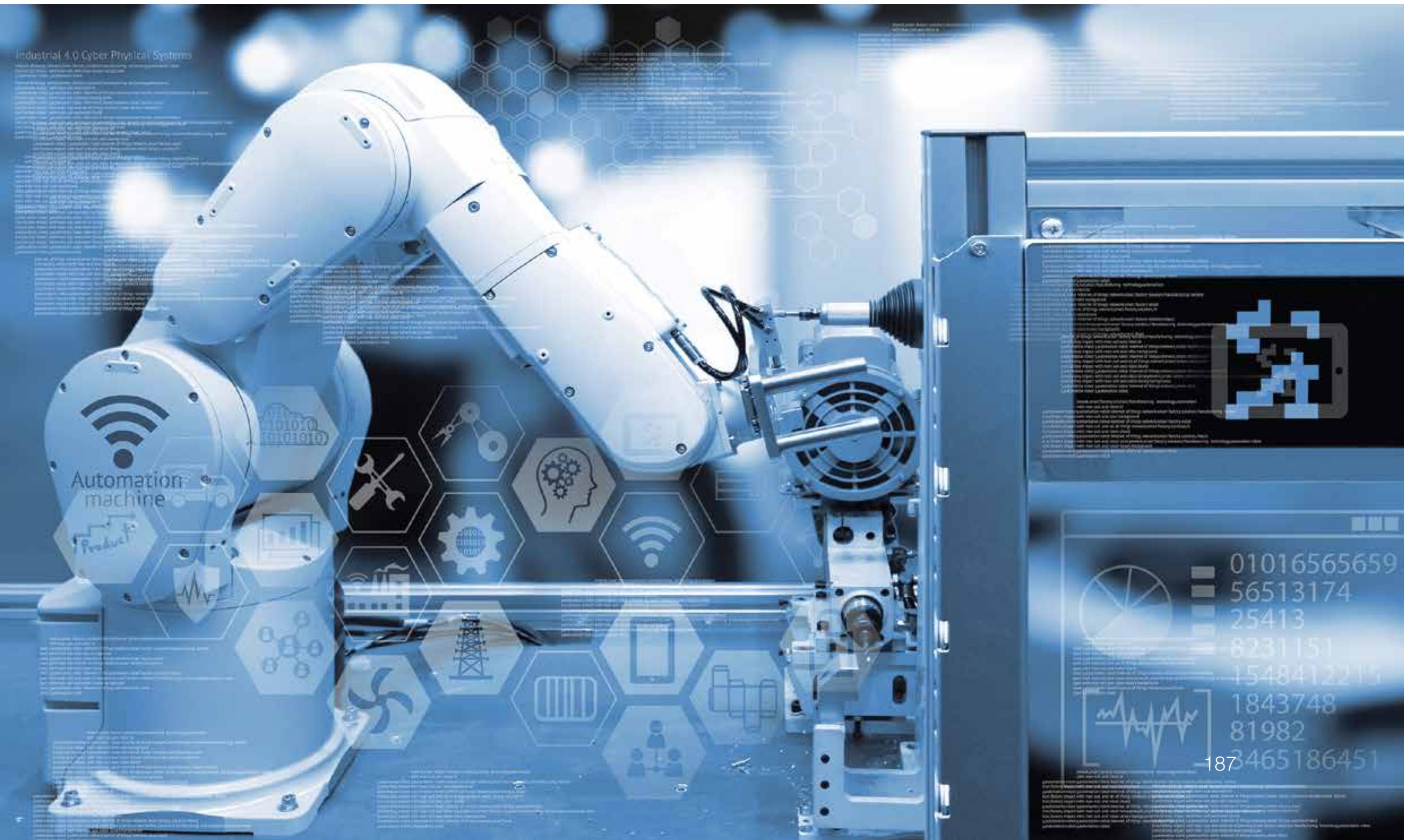
One may have imagined a few decades ago, when the automated teller machine (ATM) was invented, that the job of the bank teller would soon disappear. However, today, even with 3.5 million ATMs installed worldwide, the global banking industry employs more clerks in local branches than they did when ATMs were first introduced (Proverb, Gera & Burelli, 2016). The successful proliferation and widespread use of ATMs demonstrates that customers are willing to interact with machines for simple, routine transactions. However, that ATMs have not eliminated the need for bank tellers reveals that human interaction is still preferred by customers for many other transactions.

From a macroeconomic perspective, automation can impact jobs in many ways. The huge concern today over the destruction of jobs by robots typically focuses on only one of several effects of new technology, particularly its displacement effect (Asian Development Bank, 2018). Jobs that involve mostly automatable tasks can and will most likely be displaced. However, automation also increases productivity in the sector in which it is adopted. This means more output can be produced with the same or fewer inputs, including labour, thereby lowering production costs. Under normal market conditions, lower production costs can lower the prices of goods in real terms, increasing demand for such goods, which in turn can increase demand for inputs, including labour. Automation can also create new tasks involving its upkeep, thereby increasing the number of jobs in the sector.

Automation in one sector can also impact jobs in other sectors. Spillover effects can trickle downstream to sectors that benefit from cheaper or better quality inputs from the newly automated sector, thereby lowering costs for that sector, possibly stimulating demand for its products and creating more jobs there. However, spillover effects benefit sectors upstream through increased demand for their products as the automated sector's output expands, thereby also possibly generating employment upstream. Finally, when automation leads to increased productivity and higher incomes, greater demand for the products of other sectors may create more jobs there.

The net impact of automation across the economy that results from this myriad of simultaneous effects and their consequences will be highly dependent on the elasticities of supply and demand that govern these relationships. For example, when automation displaces workers employed in a specific job, wages decrease and the supply of labourers interested in that job is expected to decrease until the labour market reaches a new equilibrium. If the elasticity of labour supply is high, labourers will quickly shift away from lower-paying jobs and try to find relatively better paying ones, easing the negative pressure on wages. However, if labourers are stuck with highly-specialised skills or are unable to obtain new skills required for other jobs, wages will remain low or continue to decrease. Similarly, if automation reduces production costs, resulting in lower prices of a particular product, the potential increase in demand for such product and the resulting increase in the labour input requirements in that sector will depend on the responsiveness of buyers of that product to changes in its price.

Indeed, the complex relationship between technology and jobs makes it difficult to predict what exactly will happen in the future. Many of the jobs that exist today look very different from how we imagined them to be before technology changed them. Further complicating the matter is the huge difference that context makes in the actual impact of new technology. The relationships and their elasticities, which will ultimately determine the net effect of automation and artificial intelligence on the nature of employment in the future, vary widely across developed and developing countries.

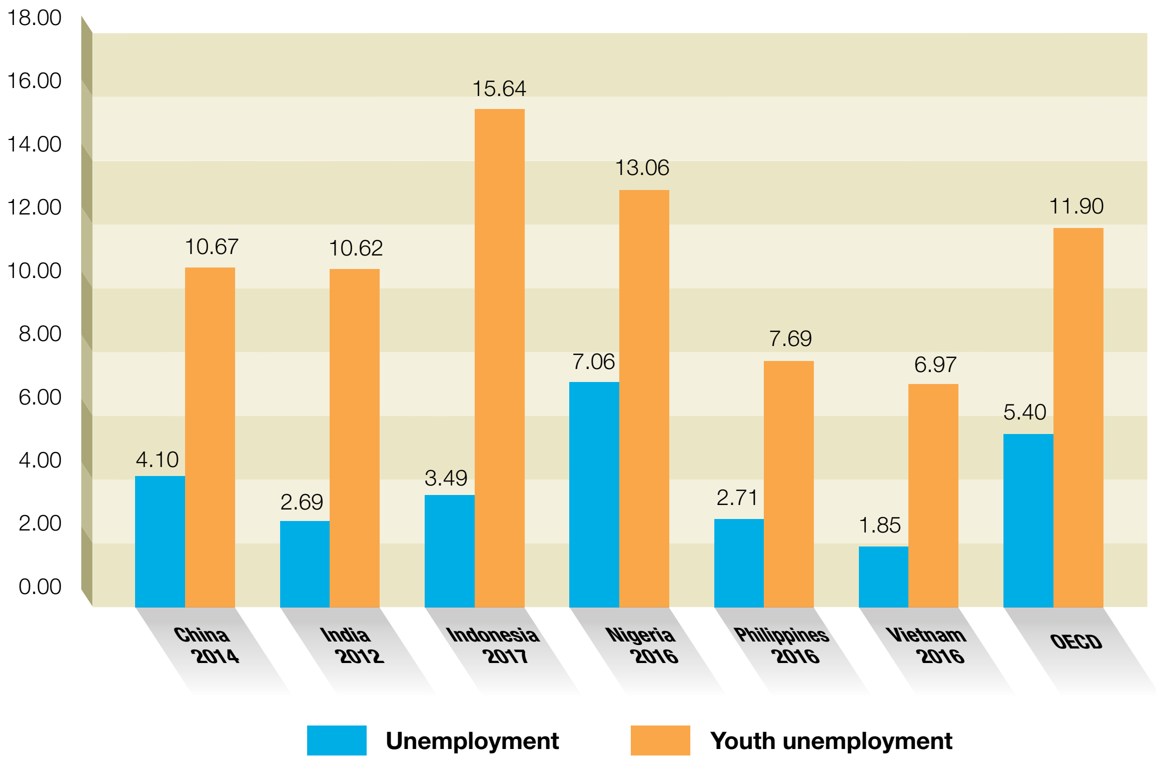


Why Developing Countries Should Still Worry About Automation

Although there are convincing arguments for developing countries to be hopeful that automation and AI will increase labour productivity and create new jobs resulting in a positive net impact on the economy in the long term, the disruption that the Fourth Industrial Revolution will cause in the short term will certainly be a major concern. Developed and developing countries alike will have to deal with massive disruption, but developing countries will face particularly higher risks of (1) worsening unemployment, especially among youth, and (2) increasing inequality, which may further contribute to (3) persistent underdevelopment.

As much as new jobs may be generated in both automation-enabled and automation-enabling sectors in the future, present jobs will certainly be affected and unemployment will probably increase. Younger workers with lower skill sets and less experience may be particularly vulnerable. In developing countries, youth unemployment tends to be far worse than total unemployment (Figure 8). This presents a double-edged sword, because although younger workers tend to be more trainable and more adaptable than their older peers, higher levels of youth unemployment may lead to increased crime and heightened social unrest, which may undermine economic progress.

Figure 8: Unemployment and youth unemployment rates of selected economies



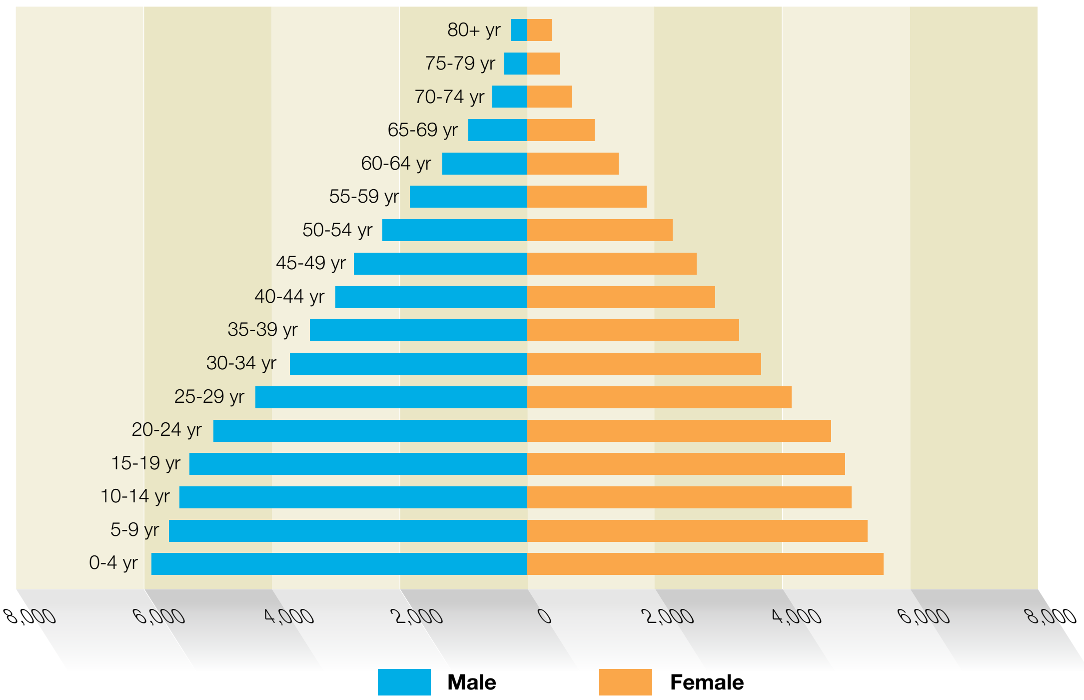
Sources: OECD, 2018. Unemployment Rate. Available at: https://data.oecd.org/unemp/unemployment-rate.htm#indicator-chart; OECD, 2018. Youth Unemployment Rate. Available at: https://data.oecd.org/unemp/youth-unemployment-rate.htm; World Bank, 2018. World Bank Open Data. Available at: https://data.worldbank.org/

The problem of youth unemployment is especially important in developing countries, most of which have young populations that are expected to continue growing rapidly for years or decades to come. According to the World Bank, India and China alone will have to generate jobs for 500 million young people joining the workforce in the next 15 years. Furthermore, in Africa, 11 million young workers are expected to join the labour market every year for the next decade.

Furthermore, countries, such as the Philippines, Indonesia, Nigeria and India, all of which have very young growing populations, expect to reap a demographic dividend as the share of their working age populations grow larger than those in their non-working-age groups, as illustrated in Figures 9 to 12. In theory, this means that these countries would potentially have more workers to contribute to economic growth than those who are dependent on them as their populations boom. However, this promise can be easily undermined by the increased risk of unemployment, especially among youth, taking away the golden economic opportunity that such a demographic sweet spot is supposed to provide. When youth unemployment sparks crime, radicalism and social unrest, the promised demographic dividend may easily turn into a demographic disaster.

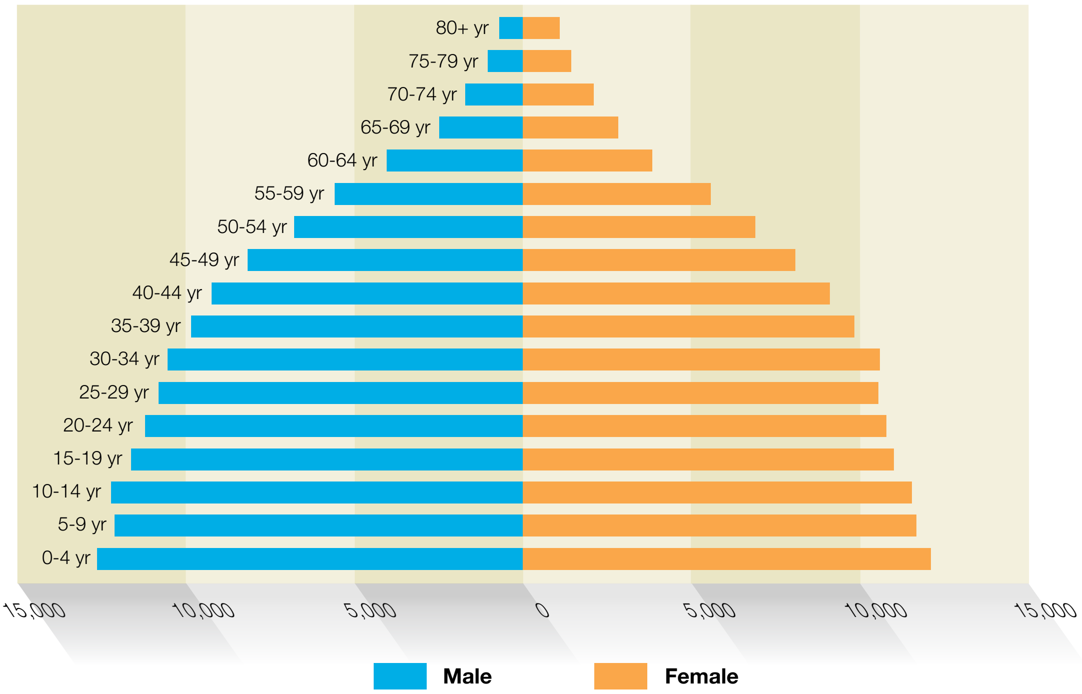
Therefore, governments and the private sector must act quickly, not just to generate new jobs for growing young populations, but, more importantly, to equip the youth with the higher level skills required to thrive in automated work environments, while providing social safety nets to ensure that disadvantaged workers do not fall between the cracks.

Figure 9: Age distribution in the Philippines, 2015 (in thousand persons)



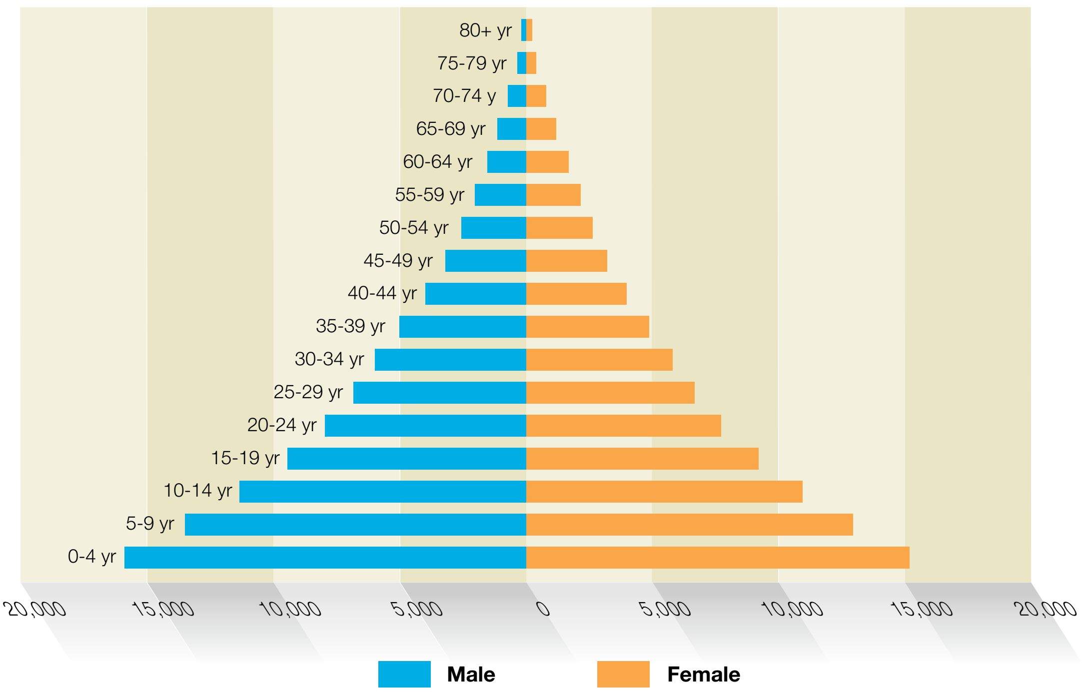
Source: United Nations Population Division, 2017. World Population Prospects 2017. Available at: https://esa.un.org/unpd/wpp/Download/Standard/Population/

Figure 10: Age distribution in Indonesia, 2015 (in thousand persons)



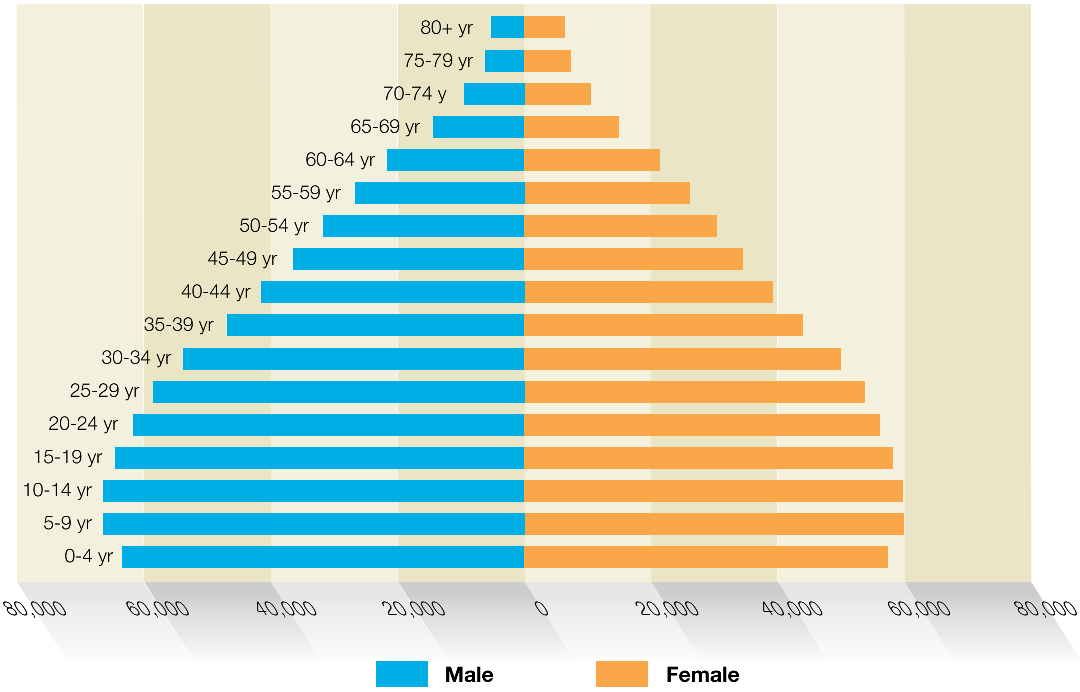
Source: United Nations Population Division, 2017. World Population Prospects 2017. Available at: https://esa.un.org/unpd/wpp/Download/Standard/Population/

Figure 11: Age distribution in Nigeria, 2015 (in thousand persons)



Source: United Nations Population Division, 2017. World Population Prospects 2017. Available at: https://esa.un.org/unpd/wpp/Download/Standard/Population/

Figure 12: Age distribution in India, 2015 (in thousand persons)

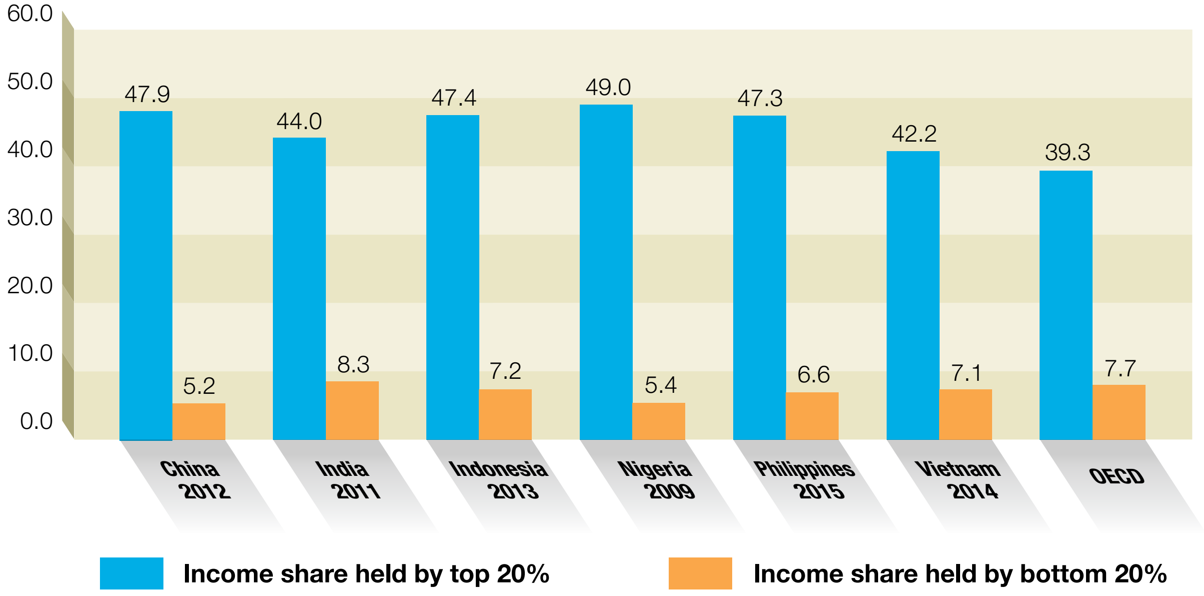


Source: United Nations Population Division, 2017. World Population Prospects 2017. Available at: https://esa.un.org/unpd/wpp/Download/Standard/Population/

Technological advancements brought about by the Fourth Industrial Revolution may also worsen inequality. The richest 20% in countries such as China and Nigeria today earn more than nine times what the poorest 20% earn (Figure 13). Income inequality undermines social cohesion and economic growth in the long term. As the Fourth Industrial Revolution unfolds, the concentration of income and wealth may further intensify. Those who have greater access to critical resources today have greater means to gain ownership or control over the technologies of the future. They also have greater means to acquire the higher skill set necessary to reap its rewards. Likewise, the new business models that take full advantage of the benefits of automation and AI will probably require considerable physical and human capital, locking future resources in the hands of those who already control such capital today. Large productivity gains expected from the adoption of new technologies would then mostly benefit elite sectors of the economy.

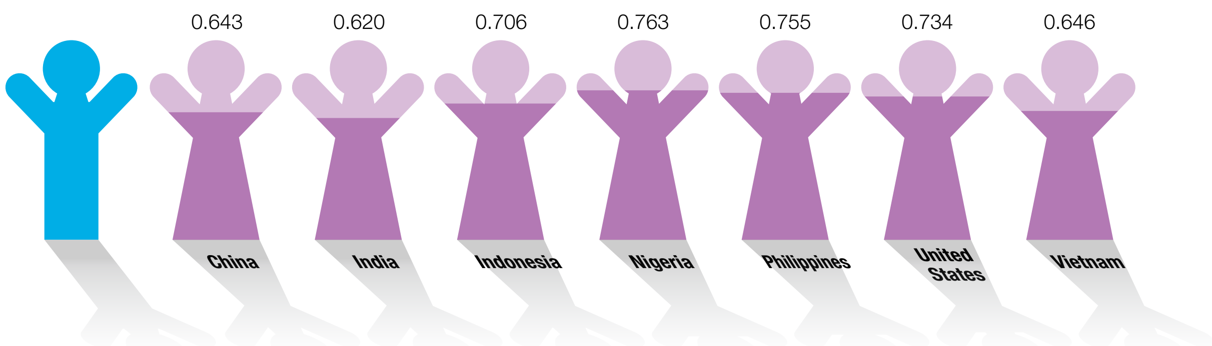
Governments and the private sector must ensure that introducing new technologies does not worsen inequalities that may permanently lock in inefficiencies. For example, the gender wage gap (Figure 14) may worsen if women are trapped mostly in jobs involving highly automatable tasks, such as those in agriculture, garments manufacturing, clerical and business support and retail/wholesale services.

Figure 13: Income share of the top 20% and bottom 20% in selected economies



Sources: OECD, OECD Income Distribution Database: Gini, Poverty, Income, Methods and Concepts. Available at: http://www.oecd.org/social/income-distribution-database.htm; World Bank, Poverty and Equity Database. Available at: https://datacatalog.worldbank.org/dataset/poverty-and-equity-database

Figure 14: Gender pay gap in selected countries, 2017



Source: World Economic Forum, 2017. Global Gender Gap Report 2017. Available at: http://www3.weforum.org/docs/WEF_GGGR_2017.pdf

Introducing new technologies may also create new sources of inequality between those who are able to take advantage of them and those who are not. A new 'digital divide' may not only exacerbate current gaps, but also create new ones, especially given that the Fourth Industrial Revolution has the potential to accelerate the returns to skills and knowledge, which may not be equally available to all.

Such inequalities and the concentration of income and wealth not only reduce economic efficiency, but also create social problems similar to what unemployment brings – crime, dissatisfaction and political instability. Although these issues affect all sectors of the economy, their effects tend to be larger and more significant in the weakest sectors. Problems of persistent underdevelopment, such as multigenerational poverty, may worsen as a result of the unequal adoption of new technologies and unequal preparedness for its disruptive effects. Therefore, extra attention must be given to the weakest and least capable sectors – the unemployed, the poor, low-skilled workers, women, minorities and youth – where disruption is likely to have more devastating and permanently debilitating effects.

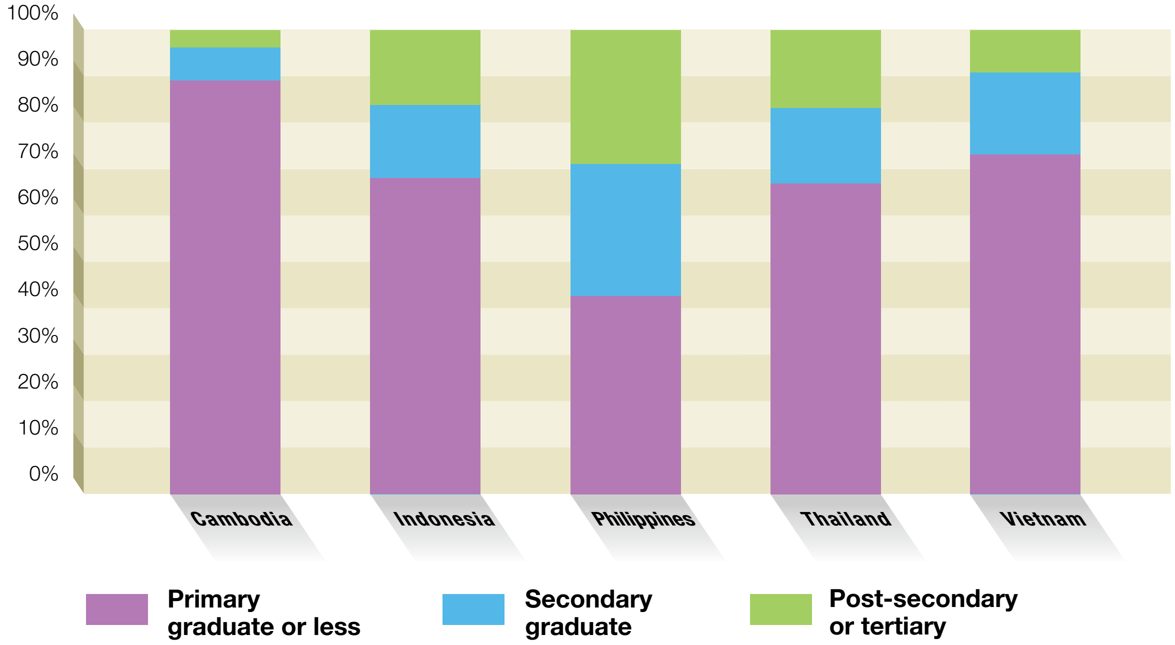
How Automation May Impact the Philippines

The Philippine case is particularly interesting given the special characteristics of its labour force, which distinguish it from its regional peers. First, the Philippine workforce exhibits a relatively high level of educational attainment among countries in Southeast Asia (Box Figure 1). Nearly 3 in 5 Filipino workers are high school graduates or have some post-secondary education, whereas 1 in 5 are college graduates (Philippine Statistical Authority, 2017). The country's young, well-educated workforce is certainly a valuable asset that it can leverage as it embraces new technologies. After all, technological change is typically skill-biased, in that its adoption tends to benefit workers with higher skills rather than those who are less skilled. Furthermore, jobs at the higher end of the spectrum of skill requirements generally face less risk of automation.

According to data from the Philippine Commission on Higher Education, the top fields that Filipino college students enrol in are business administration, education and teacher training, engineering, IT and medicine-related fields, including nursing and physical therapy (CHED, 2017). These courses typically equip students with high-level skills. However, what is problematic is the difficulty many graduates face in finding full employment in jobs that match the skills they specialise in. In early 2018, the country's underemployment rate stood at 18%, whereas youth unemployment was at 16%. The local economy has not been able to provide enough jobs to maximise the potential of the country's large pool of college graduates, which is increasing by approximately 500,000 new graduates per year. This has resulted in a surplus of skilled labour that has helped fuel the rapidly growing IT-BPO industry and the diaspora of overseas Filipino workers (OFWs) across the globe. Together, IT-BPO revenues and OFW remittances contribute more than 20% of the country's GDP (Philippine Statistical Authority, 2017).

Although the local BPO industry association places the total number of low-skill jobs that are expected to be replaced by automation and AI in the next 5 years at only 40,000 to 50,000 (Lema, 2017), some industry observers imagine the displacement of workers to be possibly far greater. The outcome will depend on the rate of adoption of the new technologies by outsourcing clients and by service providers, which in turn will depend on the relative ease and cost of such adoption. If automation and AI are driven primarily by cost-efficiency criteria, then the speed and magnitude of their impact on the IT-BPM industry will depend on how low the sector can keep its costs given the current labour-intensive setup. Given that the Philippine IT-BPM sector has developed cost-efficiency as a global competitive advantage, the replacement of human jobs with machines may not come as quickly or as widespread as some imagine. This buys valuable time for the country's industry to up-skill its workers and move to higher value activities that are at lower risk of automation.

Box Figure 1: Distribution of the highest education level of employed persons in selected ASEAN countries



Source: Chang, Jae-Hee and Phu Huynh, 2016. ASEAN in Transformation. Available at: http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/publication/wcms_579554.pdf

It is also important to assess the economic feasibility of automation in the Philippines. If the primary driver of automation is cost efficiency, then the rate of its adoption and therefore its impact on employment will differ substantially between advanced economies where wages are high and less developed ones, such as the Philippines, where workers are paid a smaller fraction. For example, autonomous or self-driving cars make far more economic sense in New York City, where a chauffeur earns US$67,000 per year, than in Manila, where a chauffeur can be hired for only US$3,000 per year (Indeed.com, 2018).

Approximately 85% of jobs in the Philippines serve mainly domestic final demand, which makes them less vulnerable to the threat of automation than those that serve foreign markets, as replacing them with expensive robots may not be economically feasible at current market conditions. The remaining 15% of jobs that are linked to global value chains, such as those in BPO companies that serve foreign clients and those in export manufacturing, do face a higher risk of automation (Philippine Statistical Authority, 2017).

In the long run, should it eventually prove to be economically feasible, widespread automation will put additional pressure on the local economy to generate jobs, but the positive effects of the new technology in terms of greater productivity and higher incomes may also help create new jobs in sectors that would actually make better use of the skills currently being underutilised, such as in business management, engineering and IT.

The positive impacts of new technology on job creation and income growth were particularly demonstrated in the Philippine experience of the ICT boom, which created not only new jobs, but also new job positions in IT-BPO and electronics manufacturing. An analysis of the country's national classification of occupations list shows that 42 new job titles were created from 1990 to 2012, most of which were ICT-related and in occupations that were cognitive and non-routine, including electronics and telecommunications technicians, database and network professionals, architects/designers and software developers (Asian Development Bank, 2018).

Not just to stay globally competitive, but also to remain relevant amidst radical advancements in artificial intelligence and automation, the local BPO industry may direct its efforts in developing competencies in using these new technologies to further increase the productivity of its workers, enhancing its competitive advantage of cost efficiency. It may also focus on enabling other industries to take advantage of these new technologies by facilitating and supporting the digitisation of its client industries. As the country benefitted from the rise of ICT-enabling sectors (e.g. electronics and telecommunications) and ICT-enabled sectors (e.g. BPO), the Philippines may benefit from the rise of the automation-enabling and automation-enabled sectors of the future.

Another unique characteristic of the Philippine workforce is that more than 20% of employment is in high-skill jobs, namely as managers, professionals and technicians. These jobs categorically face a low risk of automation, as they involve mainly cognitive, non-routine tasks. This figure is notably higher than the values reported for Thailand (14%), Indonesia (9%), Vietnam (9%) and Cambodia (9%; Chang & Huynh, 2016). However, the Philippines also has the second largest share of low-skill employment among its peers at 32%. This highlights the 'hollow middle' of jobs in the Philippines.

In developed countries, the hollowing out of middle-skill jobs has been mainly attributed to the automation of manufacturing and, to a lesser extent, the offshoring of labour-intensive operations. However, in the Philippines, the manufacturing sector has never played as big of a role in generating jobs as it has in other countries, such as Thailand or Malaysia. From the 1990s to the 2000s, the share of manufacturing in total employment remained at just 9% (Rafaelita, 2014). This means that there are relatively fewer workers in the country who are at high risk of being displaced by automation in manufacturing than in its regional peers.

Although some studies warn that the BPO industry may face the same risk of automation as export manufacturing, there is also a compelling argument that because jobs in the Philippine BPO sector mainly involve customer service work, these jobs may be less vulnerable (Sethi & Gott, 2017). Although technically feasible, chatbots and on-line platforms may not be practical substitutes for customer service agents in situations that call for human interaction and cognitive judgement. Following this argument, what were once considered 'low value-added' activities, such as customer service or technical support, may actually be less automatable than 'middle value-added' services, such as back-office accounting work or medical transcription. An important competitive advantage that customer service agents have over robots and artificial intelligence is customer preference for human interaction. Should this preference eventually change as consumers adjust to other modes of interaction or as the user interface with chatbots improve, then the risk of automation will eventually increase.

What would be particularly challenging for the Philippines then would be finding alternative employment for those in customer service work, as the skills required for higher value-added services usually require more advanced education. Based on a 2016 labour force survey, nearly 85% of call centre workers do not have a college degree. In contrast, 72% of entry-level positions in animation and 68% in medical transcription, both of which require more technical or advanced skills, are filled by college graduates (Price & Caboverde, 2017).

The local BPO industry association has recognised the need to upskill its workers and many companies have begun to invest in training programmes for their employees, both to improve employee retention and to equip them for higher value-added services (Price & Caboverde, 2017). However, training is costly and industry leaders remain uncertain about what BPO jobs would look like in the future and what specific technical skills would be needed for them. The only consensus has been that communication skills, critical thinking and problem solving remain fundamental competencies that jobs of the future will require.

Finally, the challenge of low labour productivity, although common among developing countries, is particularly disconcerting in the Philippines. Outside pockets of relatively high productivity, such as electronics manufacturing and IT-BPO, the productivity of Filipino workers has remained very low. In the latest World Competitiveness Yearbook ranking, the Philippines placed second to lowest among 63 countries in terms of labour productivity. This is where the opportunity lies for the Philippines in that automation can be used to complement its workforce to increase productivity.

Productivity gains, income growth and positive spillover effects may offset the job displacement effects of automation. To maximise these positive benefits, the Philippines will have to invest in both physical and social infrastructure that will enable the economy to benefit from the new technology.

Recommendations for the Public Sector

Historically, middle-skill jobs have been the path out of poverty for low-income workers, as the skills necessary for these jobs are relatively easy to acquire. These jobs tend to involve mainly manual and routine tasks, such as factory and clerical work, which many developing countries depend on for employment and export production. However, a recent trend observed not just among advanced economies, but also among an increasing number of developing countries, is the hollowing out of labour markets (World Bank, 2016). The traditional view was that middle-skill jobs were being lost to lower-income countries with lower labour costs, but the new realisation is that many of these jobs now face the even greater risk of being lost to automation.

Simply put, the prospects for jobs that mainly involve cognitive, non-routine tasks, especially those that require personal or social interaction, and those that are ICT- or automation-enabling will probably expand. However, those that involve mainly manual, routine tasks will probably shrink. Although an increasingly greater number of tasks are becoming automatable, the economic feasibility of automation will heavily depend on its costs and benefits relative to the status quo. This is where differences between developed and developing economies become relevant to any discussion of the possible impact of automation on jobs and education.

Much of the recent work on the topic have overlooked the importance of context when predicting the impact of new technology on the economy. Many of the tasks that are highly automatable are associated with jobs that pay much less in developing countries than in richer economies, where it makes more economic sense to replace workers with robots. Paradoxically, the low level of labour productivity that has been a major challenge to income growth and economic development in less developed countries now shields them, at least temporarily, from the onslaught of automation.

This is both a blessing and a curse. It is a blessing because it buys developing countries a little more time. It is a curse because low productivity is a development quagmire. The lower cost of labour can keep their export sectors globally competitive a little longer, assuming the absence of protectionist policy interventions in favour of reshoring. More importantly, jobs that service mainly domestic demand are less likely to be automated for as long as the current labour-intensive approach continues to be cheaper than the adoption of imported new technology, which may make more economic sense in advanced economies than in poorer economies, especially where labour is cheap and the necessary infrastructure is patchy.

However, although low wages may keep workers in developing countries competitive for a while, that wages are low because their workers are not very productive makes this false competitive advantage unsustainable. This low-level equilibrium is a poverty trap that keeps the most vulnerable workers in the economy stuck in jobs that exist only as second best. To truly remain globally competitive, developing countries must prepare their workforce and build the necessary support infrastructure to take advantage of automation.

Countries that currently face low levels of productivity may eventually have the most to gain from adopting new technologies that can radically increase their productivity. This is what happened when the Philippine IT-BPO sector took advantage of advancements in ICT. This is what happened when the Chinese export manufacturing sector took advantage of advancements in robotics. However, the key to successfully harnessing the potential impact of new technologies on productivity is increasing the economy's 'absorptive capacity' – the ability to learn and implement the technologies and best practices of the advanced economies that developed them (Dahlman & Nelson, 1995). After all, technology can drive economic growth only if it is harnessed to make the best use of available resources. Developing countries must therefore use the extra time they have wisely.

Central to enhancing the economy's absorptive capacity is investment in education. Strong government support will be needed to reform the education system to make it more relevant and agile. The objective of such a reform must not be about equipping future generations with skills and competencies that make them automation-proof, but rather those that make them automation-ready. The workers of the future will have to be equipped with the cognitive training and communication skills necessary to take on jobs intensive in non-routine cognitive, social interaction and ICT tasks that are least likely to be automated in the future. Equally important is the investment in 'digital skills' that will enable workers to use new technologies to augment their productivity. Workers must learn how to work with robots and computers. Those who are not equipped with digital skills will probably remain trapped in low-paying jobs or eventually lose employment. Professionals, business executives and entrepreneurs must learn how to access, adopt and apply automation, artificial intelligence, data analytics and other technological advancements that define the Fourth Industrial Revolution. Those who do not will probably lose business to their more tech-savvy competition.

This highlights the risk that automation may further worsen inequalities in developing countries. Workers who are trapped on the other side of the growing digital divide will probably face stagnant wages and limited income opportunities. To curb worsening inequality, developing country governments will have to invest even more heavily in human capital development to bring the entire workforce up to speed, while improving connections between industries, universities and vocational schools to make higher education and vocational training more responsive to market demand and therefore more efficient.

However, the critical role that developing country governments play in ensuring that their economies thrive in the Fourth Industrial Revolution extends beyond education reform. Although all industrial revolutions in the past resulted in net positive long-term gains in terms of productivity and quality of life, the massive disruption they caused often resulted in social upheaval and political movement, some with negative effects on economic growth and social harmony. Therefore, government must mindfully navigate the next industrial revolution, adopting social and economic policies that take on a systems-wide approach to preparing for the changes ahead.

Both the magnitude and the uncertainty of the nature of disruption require governments to take action on multiple fronts of socio-economic policy to achieve inclusive and sustainable growth. Government must prioritise physical and social infrastructure development, regulatory and competition policy and social protection alongside skills acquisition and capacity building.

For an economy to remain globally competitive, investments in digital infrastructure – broadband Internet, mobile telecommunications, digital platforms and cloud computing – must be increased, while ensuring an effective regulatory framework to promote competition and ensure fair access to big and small players alike. Digital platforms offer promising solutions to current market inefficiencies, but strong economies of scale and network effects make them susceptible to market dominance by increasingly powerful firms. When new technologies are costly, digital transformation tends to be uneven, resulting in even larger productivity gaps between firms with and without adequate resources. In particular, small and medium enterprises, often beset by limited access to finance, talent and technology, need greater support from the public sector in accessing new technologies to enable them to catch up with larger firms in terms of productivity. Developing countries must find creative solutions to the challenge of making proprietary new technologies widely accessible, while protecting intellectual property rights and incentivising innovation.

In terms of social policy, safety nets must be put in place to help absorb the impacts of automation on unemployment, especially among those in disadvantaged sectors, such as agricultural workers, urban and rural poor, women, youth and minorities. Access to retraining and skills upgrading among the general working population should be a government priority, but appropriate safety nets should also be put in place for those who in spite of their best efforts are unable to secure stable sources of livelihood due to disruption. Meanwhile, employment-based welfare policy should be reviewed and expanded to cover the increasing number of workers in the gig economy. Otherwise, digital transformation may simply perpetuate the socio-economic insecurities already faced by millions of workers in the informal sector.

To address these challenges, it may be useful for government to organise an interagency task force to unify and coordinate its efforts. Such a task force may also be expected to have a broader perspective on issues, rather than a narrow focus on specific mandates. For example, the department of trade must work closely with the education ministry to ensure that new workers meet future needs laid out in its industry roadmaps and must also coordinate with social welfare to prepare appropriate social safety nets for displaced workers. Otherwise, government agencies may become fixated on their narrow mandates, reducing their effectiveness in solving the increasingly complex issues of automation.

Amidst the debate on the possible impacts of the Fourth Industrial Revolution and how the public sector should respond to it, there is a line of thought arguing for governments to adopt new industrial policy to actively promote the rapid and extensive adoption of automation and AI, attempting to spur the predicted structural transformation rather than simply preparing for and responding to it as it unfolds. Governments must tread with caution in taking this approach.

The economic case for industrial policy is based on the premise that market failure prevents industrialisation, thereby necessitating government intervention to correct the problem. Most country governments have attempted this with varying success. Often a specific industry (e.g. automobile manufacturing or shipbuilding) is picked as a potential 'winner', which is then given special government support in the form of subsidies and protection from foreign competition. If successful, the chosen industry thrives and government investments pay off handsomely. If not, valuable government resources that could have been allocated elsewhere are lost. In many instances, the intervention results in a 'second-best' outcome where the chosen winner emerges in a monopolistic market fraught with inefficiencies of its own.

Nonetheless, when the sources of market failure are easily identified and the relationships between economic variables are well-defined, governments may implement industrial policy with great confidence of achieving the desired outcome. However, when the variables and their interrelationships are complex, intervention may create more problems than it intends to solve. As the socioeconomic impacts of the Fourth Industrial Revolution are ambiguous, 'picking winners' may be a dangerous proposition to make, especially for developing countries with fragile economic trajectories. The public sector is better advised to focus on bridging gaps and 'saving losers'.

Reimagining Education

Automation may mark the end of so-called ‘Factory Asia’ and the demise of such a model as the holy grail for aspiring low-income countries. Advances in robotics and artificial intelligence will decrease the competitiveness of low-cost, low-skilled labour – often the primary advantage of developing countries. Therefore, at the centre of the public sector’s response must be education reform aimed at equipping current and future workers with the new higher-level skills they need to remain globally competitive.

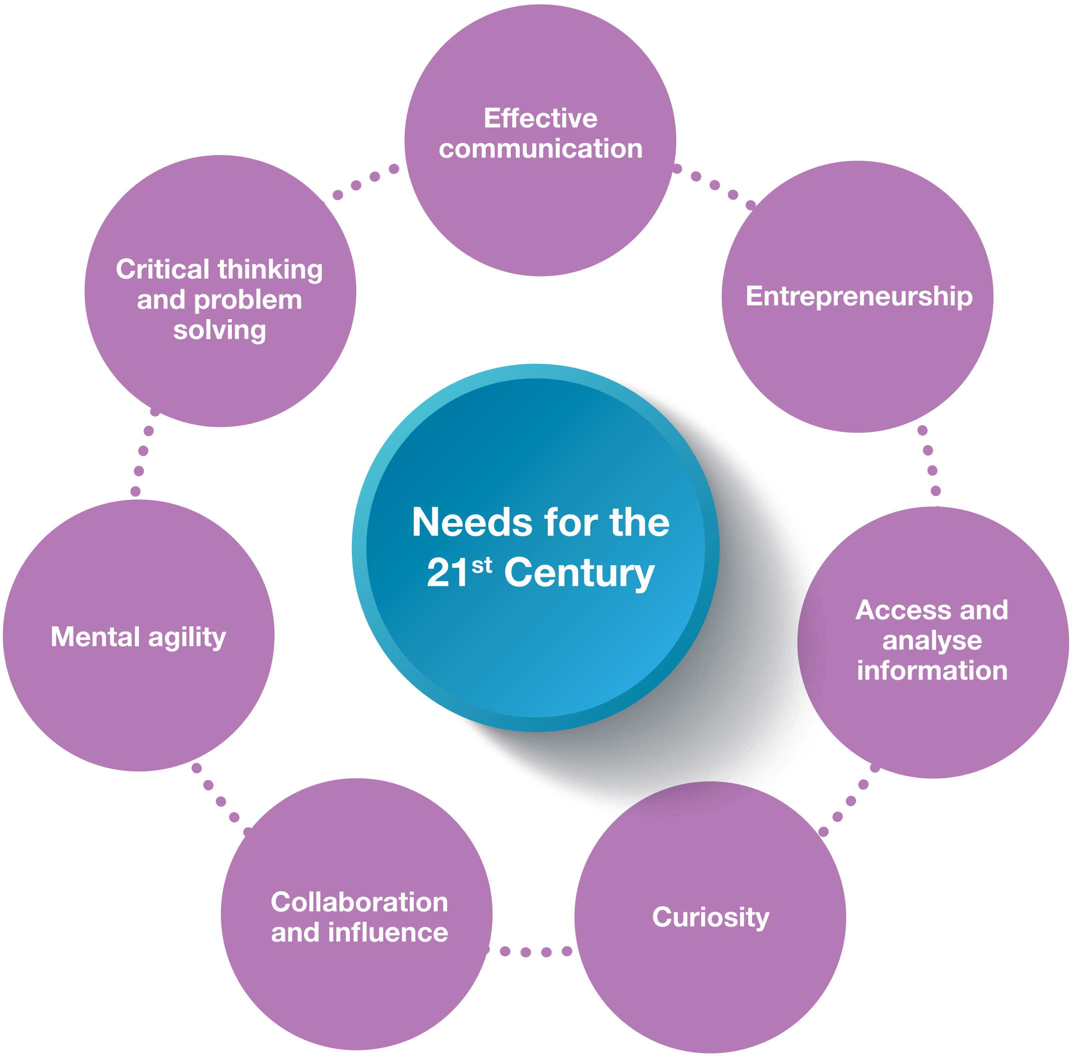
However, poor basic education remains a perennial problem for most developing countries. Although enrolment and completion rates have improved for many countries over the last few decades, students’ basic literacy and numeracy skills remain inadequate. As a result, even those who complete primary and secondary education often lack employable skills when they enter the job market.

The most common solution has been to make students stay in school longer. Indeed, faced with slim job prospects out of high school, many students aspire for higher education in the hope that this will increase their employability. For example, in the Philippines gross tertiary enrolment increased from 27% in 2005 to 36% in 2014 (Philippine Statistical Authority, 2017). The problem about relying on longer schooling to equip future workers with employable skills is that the longer schooling takes, the more difficult it is to keep students in school. Opportunity costs in the form of forgone income substantially increase as students reach working age. Furthermore, although future gains to schooling exceed foregone employment opportunities in the present, immediate financial needs may have to be prioritised. In 2017, tertiary education in Philippine state colleges and universities were made tuition-free, sparking contentious debate on whether the government, given its limited resources, should spend more on providing free higher education to all or focus instead on improving basic public education. Some critics argued that tuition-free education would primarily benefit wealthier students, as only 12% of students at state institutions came from low-income households (Orbeta & Paqueo, 2017).

In the advent of the Fourth Industrial Revolution, the issue becomes more complicated as the challenge of developing higher level skills make the challenge of developing basic foundations skills even more critical. Is the solution simply to make students stay in school longer? Not necessarily.

Developing country governments will have to quickly to improve not only the quality of both public and private education, but also the kind of education provided. The focus will have to shift away from training future factory workers and office clerks, with basic literary and numeracy needed to read operating manuals, write reports and generate spreadsheets. Education will have to be reimagined. Teachers will have to find better ways to develop creativity, entrepreneurship, social skills, team work, emotional intelligence and the ability to think and learn quickly at every level of schooling.

Figure 15: Common areas of core competence for the 21st century



Source: Adapted from Grob-Zakhary, Randa and Jessica Hjarrand, 2017. To Close the Skills Gap, Start with the Learning Gap. In Meaningful Education in Times of Uncertainty. Washington, DC: Brookings Institute

The Brookings Institute identifies six areas of competence for the 21st century: critical thinking and problem solving, collaboration and influence over peers within diverse groups, mental agility to adjust to unknowns and to learn new skills quickly, entrepreneurship to identify and act on new ideas, effective communication, the ability to access and analyse information and curiosity (Grob-Zakhary & Hjarrand, 2017). These foundational skills will not just help make future workers automation-proof, but also, more importantly, automation-ready. They will enable future workers to easily bridge any skills gaps that may arise as radical technologies change the way people work and do business.

As these skills are meant to be foundational, their development must begin at the primary and secondary levels of education at the same time that basic literacy and numeracy skills are developed. Curricula must be redesigned to incorporate activities that inspire entrepreneurial initiative, facilitate team work and encourage critical thinking, while teaching arithmetic or creative writing. When these solid foundations are built, even those who are not able to continue to higher education with the necessary building blocks to up-skill themselves to meet fast-changing labour market demand.

Given the wider array of basic skills to be developed, schools will have to adopt better ways of ensuring learning. Although basic literacy and numeracy are commonly assessed through standard examinations, other skills may require alternative means of assessment. Educators will have to experiment with new ways of teaching knowledge and developing skills using the same new technologies that require a change in how they teach.

One of the defining characteristics of the Fourth Industrial Revolution is the speed at which radical new technologies are emerging. It is becoming increasingly difficult to rely exclusively on a static skill set acquired some time in the past through formal education or work experience. Students will be ill-advised to simply choose the most popular degree in university and hope to secure for themselves life-long employability. As the jobs of the future are difficult to ascertain, it would be unwise to recommend specific fields of study. What workers of the future can best rely on are foundational skills that would enable them to learn new skills quickly. Future workers must not just learn how to learn, but also learn how to learn quickly.

The primary objective of basic education must not be to prepare students for higher education, but rather to prepare them for lifelong learning. This brings back the crux of quality education to the primary and secondary level. It also requires a reimagining of post-secondary education.

The current trend has been for post-secondary students to take on very specialised and career-specific degrees, fuelled by the demand for technical expertise in fields such as IT, computer science, finance and marketing. For example, even the Philippines' recently adopted K-12 reforms require senior high school students to choose between four tracks in the systems: academic, technical-vocational, sports or the arts. However, due to the high level of uncertainty about the nature of jobs in a post-automated future, 'cross-functional' and transferable skills may be more valuable in the context of rapidly changing work environments. These skills will be the bare minimum for a worker to remain employable in a world where machines and computers are able to do many of the tasks once assigned to him. This does not mean that workers will not need technical expertise or job-specific training. On the contrary, a rapidly changing work environment would require workers to re-skill frequently and quickly.

Higher education will need to become more responsive to rapidly changing industry needs. It will also have to become more practical. Without disparaging the immense value of theoretical sciences, the arts and humanities, higher education institutions (HEIs) will have to adopt pragmatic approaches to keep their graduates employable in the future. In particular, apprenticeships and other forms of experiential learning should be taken more seriously to maximise opportunities for students to learn by doing. As important as the technical skills they hone is learning how to learn on the fly. The more on-the-job training students get, the easier it becomes to retrain them in the future.

A critical obstacle to making this happen is the negative association with blue-collar work that apprenticeship and technical training have in many developing countries. As a result, many students are forced to take on 4-year Bachelor's degrees to find jobs that require technical skills that could be mastered in less time through apprenticeship or technical education, but which they actually end up not having after their university degrees. Nonetheless, employers prefer to hire university graduates even if they still require further training over those who already have the technical skills but do not have a Bachelor's degree, as they assume that those who completed university education have better foundational skills. This situation is not only inefficient, but also unsustainable once robots and artificial intelligence become more viable substitutes to expensive college graduates. This emphasises the importance of foundational learning in primary and secondary education. However, it should challenge HEIs to incorporate apprenticeship as a key component of their curricula.

The rapidly changing nature of jobs in the future will require the post-secondary education system to respond more quickly to changing skill requirements. For this reason, technical and vocational education and training (TVET) may play a crucial role especially in developing countries. TVET is typically less expensive and requires less time to complete than higher education. This makes it a more economically viable solution to the skills gap, especially in resource-constrained economies. This may also be a cost-effective way for developing country governments to quickly up-skill workers in specific areas of specialisation without having to depend on market forces to sort things out, thereby reducing the negative impacts of disruption in terms of unemployment due to job-skills mismatching.

Higher education and TVET should be seen as complements rather than substitutes. The education sector, both public and private, must recognise this complementarity to promote life-long learning. This is the only way for workers to remain employable in an automated world.

Many Chinese universities are now being converted to polytechnics, while Indonesia is expansively setting up new ones (Asia Development Bank, 2018). Universities and vocational schools should explore ways to allow students to seamlessly transfer credits so that TVET graduates can pursue higher education and university students can supplement their degrees with technical training or shift to a more vocationally oriented track. Given that curricula in higher education tend to evolve slowly, TVET programmes may be made more responsive to rapidly changing skill requirements. To maximise this potential, industry must be actively involved in programme design and delivery to make sure that students receive relevant and up-to-date training.

In one perspective, all of this can be seen as a huge challenge for developing countries that have barely succeeded in providing quality basic education to their growing populations. However, this may also be taken as an opportunity to catch-up. New technologies may aid rather than impede human capital development in less-developed countries. Geographical challenges and inadequate transportation infrastructure that prevent teachers from reaching remote villages may be overcome by mobile Internet and on-line learning platforms. Students and workers may leapfrog to learning more highly valued skill sets without having to master increasingly outdated middle level skills. Furthermore, some of the new skills do not necessarily require the same education technology and teaching methodologies that may not be available in developing countries. Entrepreneurship, social interaction and creativity may actually be 'taught' better using indigenous resources and local experiences.

Finally, the impact of radical advancements in technology, such as those that are expected from the Fourth Industrial Revolution, will highly depend on how they are put to use by the next leaders of business and society. Maximising their full potential and reaping the greatest benefits from them will require innovative thinking, creativity and entrepreneurship. Business leaders of the future must be entrepreneurs, able to quickly identify and act on opportunities and able to deal with uncertainty and the high risk of failure. They must be willing to experiment and engage in open-ended ventures. They must be highly perceptive and responsive to changing market conditions, while remaining optimistic and forward-thinking. In many developing countries, entrepreneurs will also have to be able to contend with imperfect business environments, inadequate physical and social infrastructure and weak or inexistent institutions. Grit and collaboration will be equally necessary to thrive. Whether the new technologies will enable developing economies to catch up or simply reinforce current inequalities and persistent underdevelopment will also depend on the ability of leaders, both in the public and private sector, to innovate and apply these technologies responsibly to address, rather than worsen, the socioeconomic challenges their people face.

Developing countries will arguably face greater challenges and definitely greater uncertainty as the impact of the Fourth Industrial Revolution unfolds. Differences in the economic, social and political contexts between developing countries and the more developed ones from which the new technologies of automation and AI come from are likely to result in divergence in both the timing and nature of their impact on jobs, business and the economy. Industry, government and educators in developing countries will have to work together to come up with specific solutions appropriate to the particular challenges that automation may bring to them.

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CHAPTER 6

Preparing the Future Workforce – Reskilling, Retraining and Redeploying and the Transformation of the Education System

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Preparing the Future Workforce – Reskilling, Retraining and Redeploying and the Transformation of the Education System

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Introduction

The city-state of Singapore is grappling with the economic disruption of the Fourth Industrial Revolution, which is changing how its inhabitants live and work. The disruption is a double-edged sword for tiny Singapore and its hardly 5.6 million inhabitants. Singapore is placing its bets on becoming a 'smart nation' to remain relevant on the global stage. As it attempts to harness the economic disruption to provide local companies the ability to leapfrog its limitations of size and small population to become global players, Singapore's digital strategy must also encompass the needs of its human capital to adapt and benefit from the economic disruption.

With the rise of the digital economy, the World Economic Forum projected that 7.1 million jobs could be lost globally from 2015 to 2020 due to disruptive labour market changes, with 2 million jobs being created in fields such as information technology (IT; Future of Jobs, 2016). For example, in Singapore, in 2016, the manufacturing sector expanded by 3.6%, but employment decreased by 15,000. Although the real value added of the sector as a whole increased by approximately 1.8% from 2010 to 2016, the number of jobs has decreased. Knowledge-intensive jobs are being created by robotics and driven by the rise of 3D printing and artificial intelligence. In general, jobs in the manufacturing sector have become more attractive with increasing wages, but job growth has decreased (Future of Jobs, 2016).

This chapter aims to examine strategies to reskill, retrain and redeploy the workforce in Singapore as it undergoes economic transformation. It is guided by three key questions. First, how effective are current government schemes and programmes in facilitating professional and mid-career conversions? Second, what are the hurdles in workers' reskilling and upgrading efforts? Third, with industry needs still evolving, are graduates of institutes of higher learning (IHLs) equipped with the skillsets needed to fulfil these industry needs? This chapter also provides examples of how skillsets are evolving in various sectors, such as the retail, the information and communication (infocomm) and the media industries.

Table 1: Singapore Labour Force Statistics (2018)

Singapore Labour Force Statistics	
Total Labour Force	3,657,000
Employment Rate	80.7%
Labour Force Participation Rate	67.7%
Overall Unemployment Rate	2.2%
Resident Unemployment Rate	3.1%
Resident Long-Term Unemployment Rate	2.8%
Citizen Unemployment Rate	3.3%
Income Growth Rate	3.7%
Job Vacancy Ratio	92

Source: Ministry of Manpower (2018)

Table 1 illustrates the overall workforce in Singapore in 2018. The tight manpower situation in Singapore is due mainly to an ageing workforce coupled with a low total fertility rate of 1.16 in 2017 and greater restriction on the inflow of foreign manpower due to social and political factors. Immigration and employment are major concerns. Voters signalled to the ruling incumbent government in the 2011 general elections that they were uncomfortable with the rapid increase in foreign labour since 2007. Greater restrictions have been placed on the hiring of foreign human capital since 2011, resulting in an increasing reliance on manpower in an ageing workforce.

Table 2: Age-Specific Resident Labour Force Participation Rate (%) from 2008 to 2016 (June)

Age (Years)	2008	2009	2010	2011	2012	2013	2014	2015	2016
40-44	83.4	84.4	84.4	84.9	85.4	85.7	87.1	87.6	88.2
45-49	82.8	82.1	82.4	83.7	84.4	84.5	84.7	85.9	86.3
50-54	77.5	78.1	78.6	79.7	79.5	80.0	81.8	82.4	81.4
55-59	66.6	68.4	68.3	70.2	72.4	73.2	74.2	75.5	75.8
60-64	48.8	50.6	51.0	54.7	58.1	59.7	61.2	62.4	62.8
65-69	27.5	29.9	30.9	36.2	38.6	40.2	41.2	42.2	43.2
70+	9.6	10.5	11.0	12.5	13.1	14.4	15.3	14.9	15.0

Source: Ministry of Manpower (2018)

Table 2 shows the age-specific resident labour force participation rate (LFPR) from 2008 during the Global Financial Crisis to June 2016. The trend shows that for the age group of 55 to 59, the LFPR has increased by 9.2%. Furthermore, the LFPR for the age group of 60 to 64 has increased by 14%. Finally, the LFPR for the age group of 65 to 69 has increased by 15.7%.

In the latest phase of Singapore's economic restructuring guided by the Committee on the Future Economy (CFE) report of February 2017, companies were encouraged to adapt their business models for the digital economy by leveraging on the wealth of data in their possession to target the right segment of clients or consumers (Straits Times, 10 February 2017). However, companies were unable to do so, as Singapore reportedly had a shortage of 30,000 technology specialists, including an estimated 11,000 software developers, by the end of 2017. To overcome these challenges, the CFE report highlighted training as being essential to resolving the shortages and recommended that the government and companies establish joint laboratories to develop data analytics capabilities (Future Economy, 2016).

The digital strategy for taking the Singapore economy forwards would essentially require a radical mind set change among all stakeholders, such as the government, companies and workers, to prepare for lifelong learning due to the speed of change due to disruption of business models (Business Times, 5 September 2017). In Singapore, the younger generation, including millennials, consists of digital natives and seems to be quite at ease using new technology in the workplace. This contrasts the older generation or mature workers, who are concerned about being displaced by advancing technology. Therefore, the government has implemented several schemes and incentives for retraining and reskilling with the aim of placing displaced workers into more promising jobs in growing sectors. Companies, particularly smaller ones, are also struggling to fill vacancies with candidates possessing the required skillsets. The government has highlighted that industry must strengthen links with educational institutions to ensure the employability of graduates with the required skillsets. In a survey by PwC, although Asia-Pacific companies intend to expand their operations to offer digital offerings, shortage of skills is a key problem (Straits Times, 14 April 2016).

The general framework for Singapore to achieve economic transformation and to prepare a future workforce is through the 23 Industry Transformation Maps (ITMs), which cover approximately 80% of the economy in Singapore. Each ITM consists of a growth and competitiveness plan that is supported by four pillars. One of the pillars is 'Jobs and Skills' through investment in human capital to equip individuals with deep skills to support the shift to greater value creation (ITM, Media Fact Sheet, Ministry of Trade and Industry, Singapore)[1].

The 23 ITMs (Table 3) are clustered into the following six areas: manufacturing, built environment, trade and connectivity, essential services, professional services and lifestyle. Table 10 also shows the lead government agency responsible for each sector. The Council for Skills, Innovation and Productivity (CSIP)[2] coordinates the overall management of the ITMs through the establishment of six sub-committees. Each sub-committee oversees a group of ITMs within the same broad cluster of industries. To ensure good coordination and accountability with the ITM framework, a lead government agency assumes overall responsibility for each ITM, which includes coordination among agencies and with the key partners. Similarly, a government agency takes the lead in each cluster (ITM, Media Fact Sheet, Ministry of Trade and Industry, Singapore).

[1] URL: https://www.mti.gov.sg/MTIInsights/Pages/ITM.aspx

[2] The tripartite CSIP was established on 20 May 2016. Its aim is to build on the efforts taken by the SkillsFuture Council and the National Productivity Council. It also develops and implements ITMs, as announced in Budget 2016. The CSIP is chaired by Deputy Prime Minister and Coordinating Minister for Economic and Social Policies Tharman Shanmugaratnam. It comprises members from government, industry, unions and educational and training institutions (Channel News Asia, 20 May 2016).

Table 3: List of Industry Transformation Map Clusters and Industries

S/N	Cluster	Sector	Lead Agency
1	Manufacturing	Energy & Chemicals	EDB
2		Precision Engineering	EDB
3		Marine & Offshore	EDB
4		Aerospace	EDB
5		Electronics	EDB
6	Built Environment	Construction (incl. Architecture & Engineering Services)	BCA
7		Real Estate	CEA
8		Cleaning	NEA
9		Security	MHA
10	Trade & Connectivity	Logistics	EDB
11		Air Transport	CAAS
12		Sea Transport	MPA
13		Land Transport (incl. Public Transport)	LTA
14		Wholesale Trade	IES
15	Essential Domestic Services	Healthcare	MOH
16		Education (Early Childhood & Private Education)	MOE
17	Professional Services	Professional Services	EDB
18		ICT & Media	MCI
19		Financial Services	MAS
20	Lifestyle	Food Services	SPRING
21		Retail	SPRING
22		Hotels	STB
23		Food Manufacturing	SPRING

Source: ITM, Media Fact Sheet, Ministry of Trade and Industry, Singapore

Human capital is central to the needs of the ITMs and its development has been strengthened through funding and support for key policies, such as the 'Adapt and Grow' and the 'Attach and Train' initiatives (Budget 2017, Ministry of Finance, Singapore). In addition, wage and training support are also increased under the Career Support Programme, the Professional Conversion Programme (PCP) and the Work Trial Programme.

In 2015, the Adapt and Grow (A&G) initiative reportedly assisted over 17,000 job seekers secure employment. In 2016, this figure increased by approximately 15%, half of which consisted of professional, manager, executive and technician (PMET) positions. The mismatch of skills and employment is a key concern, as ultimately it affects the productivity and aspirations of both employers and employees. A mismatch here is defined as a bad fit between ready skills available among workers and skills in demand by employers (companies). Programmes such as the PCP aim to resolve these mismatches. For career switches, they also fund training once an employer agrees to place the trainees on their payroll after their training is complete. Introduced in 2016, the Career Support Programme complements the PCP. It subsidises salaries (for a transitional period) for new mid-level employees once employers agree to hire them. After the transitional period, if an employee proves his worth, employers agree to reward them handsomely. However, key constraints are that lot of time and effort are required on an individual basis to ensure placement success. Furthermore, spaces in the programme are limited and depend on how many prospective employees the interested companies can accommodate.

The other problem of mismatch describes a situation in which employees are perfect fits for employers but they fail to 'catch' each other. A potential solution to this would be technologically refining HR practices and encouraging employers to be inclusive in hiring (e.g. by hiring older people and women with children). From an employer's perspective, it is imperative to analyse whether they can afford lengthened internships and training. If not, expectations may need to be compromised. The advice given to job seekers by the government is to constantly adapt and grow and to be unique where possible, especially in resume writing. In 2016, the placements achieved under the A&G initiative addressed more than 16,000 mismatches and overcame approximately 5,000. In 2016, under the A&G initiative, the career-matching services managed by agencies, such as Workforce Singapore (WSG) Careers Connect and National Trade Union Congress (NTUC) Employment and Employability Institute (e2i) career centres, had a placement success rate of approximately 70% for Rand-and-File and approximately 60% for PMETs.

The A&G initiative targets adults who have been working for a few years and who are now seeking new jobs or career transitions. Another scheme in place for students is the Earn and Learn Programme (ELP), which aims to increase work place exposure and on-the-job training (OJT). This programme targets fresh graduates from polytechnics and the Institute of Technical Education (ITE) to match them with jobs related to their area of study. Those under the ELP undergo a structured OJT and mentorship with the company for 12 to 18 months. Since its inception in March 2015, 40 ELPs covering 23 sectors have been launched.

Table 4: Industry Transformation Map Targets (2018)

S/N	Industry	Value Added	Job Creation	Target Year
1	Sea Transport	S$4.5 billion	5,000	2025
2	Air Transport	-	-	-
3	Logistics	S$8.3 billion	2,000	2020
4	Land Transport	-	8,000	2030
5	Wholesale Trade	-	-	-
6	Precision Engineering	S$5.2 billion	3,000	2020
7	Energy & Chemicals	S$12.7 billion	1,400	2025
8	Marine & Offshore	S$5.8 billion	1,500	2025
9	Aerospace	S$4 billion	1,000	2020
10	Electronics	S$22.2 billion	2,100	2020
11	Construction	-	-	-
12	Real Estate	-	-	-
13	Security	-	-	-
14	Environmental Services	-	-	-
15	Education	-	3,000	2020
16	Healthcare			
17	Professional Services	S$2.7 billion	5,500	2020
18	Financial Services		3,000	-
19	ICT & Media		3,000	2020
20	Retail	-	-	-
21	Food Manufacturing			
22	Food Services			
23	Hotel			

Source: ITM, Media Fact Sheet, Ministry of Trade and Industry, Singapore

Table 4 shows the projected jobs' creation and value added for various sectors. These targets were established by the relevant agencies in the Singapore government. To achieve these employment targets, for operational purposes, each ITM must be designed around the needs of the specific industry. As the leading governmental agencies develop their respective ITMs, they will be able to examine in depth the industry landscape and future trends and will need to develop a range of initiatives that could systematically raise productivity, develop skillsets, drive innovation and promote internationalisation. In this process, the ITMs will have to collaborate with small and large companies, the Trade Associations and Chambers, unions, individuals and the government (ITM, Media Fact Sheet, Ministry of Trade and Industry, Singapore).

In Singapore's transition from a conventional to a digital economy, in terms of reskilling and retraining its human capital, the skills framework for the respective 23 ITMs provide useful indicators of the skills required by industry in the near future and the shortage of human capital in specific industries. Some key strategies unveiled to assist in filling the skills' gaps include the A&G initiative, through the processes of career enhancement and employment support enhancement. Career enhancement matches services to help job seekers find suitable jobs and to minimise missed matches. Employment support enhancement through career conversion and wage support programmes minimises jobs, skills and wage mismatches.

Leadership and Digital Skills

Singapore's key challenges are to increase the pace of digital innovation and have business leaders with the ability and skills to collate all generated data in a way that helps keep their companies competitive. In this regard, businesses that are keen to leverage technology for growth must look for leaders who not only understand how the massive amounts of data available to the company could increase competitiveness and productivity, but also are able to identify the opportunities and threats that such data represent (Business Times, 3 December 2014). In this regard, companies are recruiting digitally proficient and strategic executives across all industries. The demand for chief digital officers able to make effective use of mobile and digital platforms to formulate strategies across all sectors has surged.

The government has estimated acute shortages in several sectors. For example, in the information and communication technology (ICT) sector, which employs an estimated 150,000 workers, the skills shortages in the areas of cybersecurity, data analytics and the development of network infrastructure are pressing (Straits Times, 2 November 2016). Although companies have addressed these skills shortages by importing foreign labour, this has decreased wages, resulting in local human capital avoiding this sector and thereby leading to more demand for foreign human capital (Straits Times, 2 November 2016). The Infocomm Technology Federation is concerned that with the rapid technological changes happening, IHLs may not sufficiently prepare students to work in the industry (Straits Times, 2 November 2016). In addition, students who enrol in IT courses may end up in different sectors, such as banking and finance.

Another growing concern is that PMETs, who account for approximately 54% of the workforce, are at risk of being displaced due to increasing automation (Business Times, 28 July 2017). This problem of mid-career switching must be addressed through PCPs, which require intensive resources, such as career counselling, reskilling and placements in alternative jobs within the same or different industry. The human capital in the following five industries are most at risk of increasing technological disruption via increased automation: healthcare, wholesale trade, infocomm and media, financial services and professional services. However, these five industries also have great potential to create new employment for PMETs (Straits Times, 22 July 2017).

Table 5: Occupational Distribution of Employed Residents (2016-2017)

Occupational Distribution of Employed Residents	
Professionals, Managers, Executives & Technicians	56.1%
Clerical, Sales & Service Workers	22.8%
Production/Transport Operators, Cleaners & Labourers	21.1%

Source: Ministry of Manpower (2018)

Table 5 shows that the percentage of workers who are in the PMET category are more than double that in the clerical, sales, production and transport sectors combined. The re-entry of human capital into employment, especially mid-career, represents another aspect of the human capital challenge. To assist human capital re-enter the workforce, the NTUC launched the Returner Work Trial Programme. Under this programme, local PMETs who have been unemployed for 2 years are offered employment opportunities to ease them back into the labour market. Employers who partner with the programme offer structured OJT in an arrangement lasting 6 months and pay these returning PMETs an allowance of S$2,500 per month. This allowance sum is derived from the WSG agency, which provides S$1,500, and the employer, which provides at least S$1,000 (Business Times, 28 July 2017). As an added incentive, employers receive an additional one-off bonus of S$3,000 if they can employ and retain a returning PMET in a contract position of 12 months or more for at least 3 months (continuous) following the completion of the work trial.

Education

The stakeholders in the education system need to improve their understanding of which skills are readily available in the working population, which skills are in greatest demand by industry and where the greatest skills gaps exist. Thereafter, the appropriate reskilling pathways towards new employment opportunities have to be created with the relevant stakeholders. As education becomes less of a linear process and moves towards a modular and continuous cycle, the delivery mode and institutional framework may need to evolve with it (World Economic Forum, 2017). In the emerging new education and training ecosystem, some job preparation functions are performed by formal educational institutions in classroom settings, some components are offered on-line and some are managed by private educational firms (Future of Jobs and Jobs Training, Pew Center, 3 May 2017).

In terms of the educational framework, in a means to address the needs for future skills, the Infocomm Media Development Authority has worked with the Ministry of Education (MOE) since 2016 to conduct ITE Code for Fun enrichment programmes in schools. It uses a mix of robotic kits, from basic ones, such as Lego Wedo and MoWay, to more complex microcontrollers, such as Arduino (Straits Times, 11 May 2017). By 2017, 128 out of more than 300 primary and secondary schools were on board and approximately 56,000 students were trained. Google also rolled out the Code in the Community project, which subsidised the cost of coding lessons to teach approximately 3,000 children from needy homes until 2020 at a cost of at least SGD $1 million.

In addition, the MOE announced in February 2016 that 19 schools would offer programming as part of the new O-level subject computing. It would include courses on algorithm and data management. In addition, from 2016 to 2018, seven new subjects, including robotics and electronics, would be introduced to the O- and N-level syllabuses to promote more hands-on learning. These changes in the educational curriculum indicate the government's recognition of the new skillsets required to work in the digital economy (Straits Times, 13 October 2016).

However, the skills developed must also be industry relevant even as technological developments evolve. In this process, employers have been involved in close collaboration with vocational institutions and tertiary institutes, such as the ITE and polytechnics, so that they can play a material role in the development of courses, curricula and learning environments. In this new educational landscape, policymakers have highlighted that whereas in the past work and study were seen as separate phases in human capital development, they have now converged. In this context, entire courses have been redesigned to integrate work and study. With the need to concentrate and deliver real-time learning to workers, the course formats must facilitate self-teaching. This indicates that more learning systems will migrate on-line.

One of the more popular on-line learning portals is Coursera, which offers more than 1,000 courses on-line from 118 international institutions. The Coursera learning platform combines interactive video content with peer-to-peer forums, discussions and assessments to enable students to learn at their own pace and master the material. It has an on-line learning experience around social interaction between students taking the courses. Students can also interact through its Q&A forums and even organically form small study groups (The Edge Singapore, 18 May 2015). Learning is free on Coursera and most of the verified certification courses cost less than US$100 (The Edge Singapore, 18 May 2015).

In terms of the courses offered, some are self-directed, some are required by employers and others are hybrid on-line/real-world classes (Future of Jobs and Jobs Training, Pew Center, 3 May 2017). To increase awareness among workers concerning in-demand skills sets, on-line portals have been set up to combine information about skills' needs and available jobs. This enables employees to acquire the information they need to develop their skills and careers (Thai News Service, 4 April 2017).

What pathways need to be in place to prevent mismatches between the skills required by industry and the skills provided by educational institutions? Governmental agencies, such as the WSG, Skills Future Singapore and the e2i, are working closely with industry to map the skills required in various economic sectors. Using the skills framework under the 23 ITMs, these leading governmental agencies provide the necessary signals to educational providers and relevant companies to develop pathways to address the skills gaps.

The skills framework for different industries also provides indicators to assist employees and employers to appreciate the need for continuous skills development (Thai News Service, 4 April 2017). Tertiary institutes have also developed courses in consultation with industry to support continuing education. One of the key educational providers, the ITE, which was established in 1992, has increased in importance in terms of providing mature learners already holding a degree or diploma continuing education. The ITE is the sector coordinator for land transport, restaurant operations and landscape sectors and in this context collaborates closely with industry according to specific industry trends and identifies the new skills required (Business Times, 27 May 2017).

Mature students accounted for 4% of the annual intake in 2014, which increased to 10% in 2016 (Straits Times, 9 October 2017). The number of mature workers who enrolled in 'bite size' modules of 7 to 60 hours were less than 1,000 in 1996, but increased to 5,000 in 2016 (Straits Times, 2 July 2016). Twelve hundred industry trainers from over 250 companies were groomed by the ITE to conduct OJT.

Companies could also provide training to their employees so that they could remain in the workforce longer and for further career advancement (Straits Times, 2 July 2016). To support companies and employers, the ITE also trains professionals to conduct OJT via the train the trainer model. For example, Fujitec Singapore, which services and sells escalators and elevators, runs an in-house Nitec course on lift and escalator technology in collaboration with the ITE. By sending its own staff to conduct lectures and coach trainees in practical skills, Fujitec is able to groom skilled technicians (Straits Times, 13 October 2016).

In the age of the digital economy, tertiary education providers are on the brink of a new education paradigm to prepare students with skills that make them relevant in a fast-changing world. Skills will be predominantly based on the Internet and data transfer, leading to the concept of remote and flexible work arrangements. Educators must equip students with new skills and abilities to make them relevant in a fast-changing digital world (Business Times, 11 May 2015).

Table 6: Highest Qualification Attained by Resident Workforce Over Age 15

Highest Qualification Attained by Resident Workforce Over Age 15	1996	2006	2015
Primary and below	41.3%	37.5%	28.7%
Secondary	32.3%	32.1%	28.6%
Post-secondary (non-tertiary)	10.0%	11.5%	18.9%
Diploma and professional qualification	4.2%	9.1%	14.1%
Degree	12.2%	31.0%	50.7%

Source: Data.gov website, Government of Singapore

Table 6 shows the various educational attainments of the working population. Although the trend indicates that workers are better educated, in the cycle of continuous learning, which core skills should be promoted so that workers can build on them to ensure that they are adaptable to the evolving employment landscape? The Global Industry 4.0 Survey by PwC highlights that from the point of view of companies, the biggest challenges centre upon internal concerns, such as culture, organisation, leadership and skills (PwC, 2016). The absence of a digital culture and the right training are key challenges. The lack of skills or competencies when it comes to utilising data analytics is a main problem (PwC, 2016). In companies, even brands, the function of HR must shift from a generalist model to an HR partnership model. The function of HR organisation must focus on understanding the needs of businesses and delivering value-added solutions (Deloitte University Press, 2015).

Table 7: Field of Study of Degree Holders in Resident Labour Force (2017)

Field of Study of Degree Holders in Resident Labour Force (%)		
Business & Administration	35.2	**32.1**
Engineering Sciences	20.3	**24.1**
Humanities & Social Sciences	10.6	**11.1**
Information Technology	8.0	**8.9**
Natural, Physical, Chemical & Mathematical Sciences	5.9	**7.7**
Health Sciences	5.5	**4.3**
Education	4.1	**2.2**
Mass Communication & Information Science	2.6	**3.0**
Architecture, Building & Real Estate	2.3	**2.8**
Fine & Applied Arts	2.0	**1.4**
Law	2.0	**2.0**
Services	1.3	**0.4**
Others	0.1	**0.1**

Source: Ministry of Manpower (2018)

Table 7 above shows that the degree holders in the workforce are segmented according to discipline. With the increasing need for educational providers to provide employable skillsets for fast-evolving industries, such as ICT, famous brands with global presence have partnered with educational institutes to address this need. For example, Huawei has agreed to establish an ICT Academy in Singapore with Nanyang Polytechnic (Asiaone, 24 February 2018). Under the Memorandum of Understanding (MOU), the Huawei Authorised Information Network Academy enables NYP to deliver Huawei certification training to their students. The MOU also strongly emphasises addressing the shortage of ICT professionals in Singapore through joint research, education and training programmes and requires both parties to establish a platform for technical collaboration between industry and government partners (Tendersinfo, 24 February 2018).

Another MNC, Proctor & Gamble (P&G), has also established Singapore as one of its global hubs for innovation and talent development (Thai News Service, 2 May 2017). P&G employs approximately 400 researchers at its Singapore Innovation Centre and trains over 500 managers annually at its Asia Leadership Development Center. P&G's E-Center, the first digital innovation centre outside of the US, will have the capabilities and mandate to develop digital solutions in supply chain management, analytics and e-commerce for the company's Asia-Pacific operations. P&G will invest more than US$100 million in the E-Center by 2022 and will train 40 employees to assume new roles at the E-Center. P&G will also work closely with IHLs to co-develop industry-relevant curricula in digital skillsets (Thai News Service, 2 May 2017).

Digital transformation is expected to add US$10 billion to Singapore's economy by 2021. However, companies will need to accelerate their digital strategies to reap the rewards of the digital economy. However, the majority of business leaders believe that more can be done to bridge the skills gap among workers, resulting in an increasing demand for professionals with such skills (Enterprise Innovation, 6 March 2018). Despite the benefits of digitalisation, companies still believe that investing in digital technologies is expensive and difficult with their limited manpower. To address these needs, IHLs, including polytechnics, have been tasked to offer programmes with in-depth knowledge and applications to transform and digitalise businesses (Enterprise Innovation, 6 March 2018).

However, among adult learners, the Survey of Adult Skills (OECD, 2013) shows that in most countries, significant shares of adults have trouble using digital technology, communication tools and networks to acquire and evaluate information, to communicate with others and to perform tasks (OECD, 2013). Adult learners also lack confidence in their ability to use computers. In contrast, younger adult learners are likely to be computer proficient and able to use technological tools to solve problems (OECD, 2013).

Retail Sector – Leveraging Technology

In 2016, the retail industry had approximately 125,000 workers in 16,000 companies (Business Times, 22 August 2016). Companies are undertaking digital transformation with traditional retail moving into e-commerce, driving the demand for technology professionals (Business Times, 20 January 2017). Although the digitisation of the retail sector is transforming the industry, this requires workers to reskill. With the expansion of digital lifecycles, customers and clients have many more choices and higher expectations and it is essential for businesses to understand their changing needs and place them at the centre of decision making (Business Times, 18 April 2017). Companies that are able to gain their customer insights are able to grow faster than their competitors as they look to utilise customer data as their greatest business asset.

Singapore's retail industry is evolving from a brick-and-mortar template into omni-channel engagements to combine the best of off-line engagements with the most measurable and personalised on-line connections with customers (Business Times, 6 October 2014). Therefore, the starting point for digital executives would be digital consumer marketing skills towards a wider range of digital leadership skills due to the challenges and opportunities that big data and digital risk management represent across entire businesses.

In the retail industry, with the pursuit of the omni sales model, businesses are looking to upgrade their B2B or employee digital user experiences to achieve the standards that their consumers are demanding. This would mean that companies require executives that are able to capture and synthesise the huge amounts of data available to companies as a result of customer interactions, supply chain feedback, production equipment reports and other sources that are key for companies to stay competitive (Business Times, 3 December 2014). What are the expectations of leaders, such as chief digital officers? They are expected to meet the growing need for consistent organisation-wide strategies to address digital business risks. The chief digital officer must be able to integrate the knowledge gained from customer behaviour analytics into highly targeted and timely customer engagement and marketing strategies through the use of cutting edge technologies, such as personalised texting and cellular geolocation (Business Times, 3 December 2014).

Visa's 2015 Consumer Payment Attitudes Survey showed that more than 70% of consumers in Singapore shop on-line at least once per month. A BMI Study also showed that on-line spending in Singapore increased from S$1.45 billion in 2009 to S$4.5 billion in 2014 (Business Times, 9 December 2016). Although Singapore's domestic retail market is considered too small, it is still a S$44 billion sector and remains an important engine of growth and source of employment.

Recruiting digitally capable employees must be embedded into companies for the evolution of their company models to take effect. As marketing comes to the fore of this evolution process due to companies' knowledge of customer behaviour and touch points, this perspective provides businesses with an overall strategic view of objectives and challenges (Business Times, 18 April 2017). Therein, the IT sector will work with engineering and other specialists to implement advanced technologies for product development to meet customer or client expectations.

Republic Polytechnic has supported the retail industry in terms of training and education by introducing the Specialist Diploma in Digital Business. The course offers in-depth knowledge and applications to transform and digitalise businesses (Enterprise Innovation, 6 March 2018). The courses are offered as part of the Skills Future ELP and the Continuing Education and Training programme.

Students apply concepts learnt and develop various strategies, including the design of e-commerce portals, in real-world industry projects. They have the option to work on their companies' projects or projects offered by RP's industry partners under the supervision of the respective companies and RP lecturers (Enterprise Innovation, 6 March 2018).

The retail industry needs to focus on what consumers actually need, which points to a converging system that is streamlined and efficient enough to enable them to purchase and collect the items they want on the same day and at a location of their choice. This would entail data and skills that understand the work flow and infrastructure platforms that are positioned with a clear understanding of new-age consumers and their daily consuming and commuting experiences. For example, given the current working hours, consumers may spend more time in the office and on the go, rather than at home (Business Times, 9 December 2016).

Therefore, logistics plays an integral role in adding value to the retail experience. Skills and solutions are needed to integrate and automate processes in a seamless end-to-end workflow in terms of a platform that is able to manage multiple channels cohesively. For example, from order fulfilment, automated inventory management systems and goods retrieval mechanisms that respond to real-time demand to self-collection ports across the island. The retail industry is reinventing itself for a digital economy and moving away from a piecemeal innovation towards a seamless and integrated process. Although companies are able to derive more meaningful information from the richness of data and analytic tools at their disposal, they must also pay heed to the cybersecurity needs of their respective companies.

With the evolution of the retail industry through changing consumer demands, especially on e-commerce platforms, government schemes and policies could look further into the specific needs of companies in this regard as they transform their business models for operational efficiency. This would include front-end technology, such as check-out systems, and back-end operations, such as warehouse and management systems. Skilled workers would need to be trained for these purposes and management would need to be able to integrate both of these components into an integral system.

To venture overseas, retail companies may need to adopt omni-channel business models. These companies would need skilled workers to manage on-line and off-line retail channels. They would also need skilled workers to market and build their brands and products in various overseas markets. For example, this could come in the form of specific softwares for various types of retail products, such as garments, jewellery, pet grooming products and food ingredients. The consumer demand for varied products may differ in terms of their consumer experience and these could be captured and analysed for better marketing strategy among companies.

ICT Industry

In 2016, the ICT sector employed approximately 150,000 workers and was projected to require another 15,000 workers by 2017 (Straits Times, 2 November 2016). From 2017 to 2020, the demand for ICT professionals in Singapore is projected to be 42,000 workers (Straits Times, 2 November 2016).

To equip infocomm workers with the relevant skillsets in ICT, the TechSkills Accelerator (TeSA) initiative was introduced, helping individuals and companies develop a supply of skilled ICT manpower (Thai News Service, 10 November 2017). By the end of November 2017, TeSA allowed more than 16,000 ICT professionals to reskill and up-skill themselves (Thai News Service, 10 November 2017). The ICT sector is expected to generate 2,500 jobs by 2018 and reach a value of S$900 million by 2020 (Channel NewsAsia, 2 April 2017). In the areas of cybersecurity, data analytics and development and network infrastructure, the number of workers could increase to 30,000 by 2020.

Table 8: Infocomm Media Professional Job Statistics (2014-2016)

Infocomm Media Professional Job Statistics	2014	2015	2016
Employment	150,200	172,800	199,800
Demand	164,800	192,900	221,100
Vacancies	14,600	20,100	21,300

Source: Infocomm Media Development Authority, Singapore, Annual Survey on Infocomm Media Manpower

Table 8 shows the numbers of infocomm media workers, the projected demand for them and the vacancies available. In relation to careers in ICT, the Ministry of Communications and Information (MCI) has also rolled out the Skills Framework for ICT, which encompasses career pathways, job roles, skills competencies and training programmes. The skills framework indicates the core workplace competencies for ICT professionals across all economic sectors and identifies 80 existing and emerging skills and competencies in the sector. The ICT Skills Framework was jointly developed by the government and industry. In terms of mid-career conversion, the Cyber Security Associates and Technologists programme is geared towards training mid-career ICT professionals in collaboration with four industry partners looking to switch to cybersecurity (Channel NewsAsia, 2 April 2017).

Table 9: Types of Employed Infocomm Media Professionals (2016)

Infocomm Media Professionals	199,800
Infocomm Professionals	180,000
Media Professionals	19,800

Source: Infocomm Media Development Authority, Singapore, Annual Survey on Infocomm Media Manpower

Table 9 shows that as of November 2017, the employed infocomm media professionals by highest qualification included, 16% diploma holders, 17% A Levels and below and 67% with a Bachelor's degree or above. In response to the demand for infocomm workers, the MCI launched TeSA in 2016 to train and up-skill professionals into ICT job roles and over 8,000 professionals were trained by the end of 2016 (Thai News Service, 8 March 2017). The company-led training programme enables ICT companies to provide OJT to individuals beyond what they intend to hire. It has seen 100% of trainees successfully placed into jobs after their training periods. The Tech Immersion and Placement Programme enables non-ICT professionals to access short immersive courses to train professionals with essential ICT skills to facilitate their placement into ICT jobs (Thai News Service, 8 March 2017).

Supplementing Indigenous Human Capital

The need for foreign human capital to supplement indigenous manpower in Singapore is highlighted by the report 'Managing Skills Challenges in ASEAN 5' by Singapore Management University and JP Morgan. The report examines the continuing increase in foreign worker inflow despite the tightening since 2011. This has contributed to a reliance on foreign workers and low productivity output due to the lack of 'indigenous capacity'. To reduce this dependence, the report points to three strategies. First, jobs should be redesigned to harness technology and tap into the work experience of displaced mature PMETs, retirees and homemakers. Second, the government should reduce the pace of change in industrial policy, as the targeted industry may need more time to mature, gain scale and depth to sharpen competitiveness and also provide affected workers with the time to keep up with the changing demand for skills (Singapore Management University, 2016). Third, more attention should be given to building soft skills and adaptability for Singapore to pursue innovation-driven growth.

However, the report recommends that the government, in targeting new growth industries to promote, should consider the adequacy of workers for the project and whether they can be trained quickly (Singapore Management University, 2016). In the event that urgently required skilled manpower cannot be sourced locally, the government should be flexible and permit companies to increase their foreign manpower quota for a specific and relatively short duration to complete the project. This would also enable local human capital involved in a project to learn new skills from their foreign colleagues. A scheme such as the Lean Enterprise Development programme could be tweaked to encompass this flexible arrangement.

Conclusion

In another report from Singapore Management University by Tan Kim Song and James Tang called 'New Skills at Work: Managing Skills Challenges in ASEAN-5', the chapter on Singapore lists the in-demand skills required by the city-state (Table 10).

Table 10: In-Demand Skills as of 2016

Industry	Emerging Job Areas and Skills
Precision Engineering/Manufacturing	Industry 4.0, additive manufacturing, advanced materials, optics and laser engineering and advanced robotics
Food Manufacturing	Food innovation and use of high technology processing methods to improve productivity
Logistics	Supply chain design and optimisation, such as the growth of e-commerce and its impact on last mile fulfilment, and data analytics
Electronics (Semiconductor)	IC design and Fin field effect transistor (FinFET) technology – FinFETs are next-generation nano-sized 3D structures, which are fast becoming the future technology of choice at feature sizes below 20 nm
Retail/Fashion & Beauty	Data analytics, omni-channel retailing, Manu design, techno cooking, revenue management, digital marketing, experience creation and leadership development in services
ICT/Media/Games	Big data analytics, Internet of Things, cybersecurity, digital experience design and transmedia storytelling
Healthcare/Social Services	Grief therapy, geriatric nursing, diagnostic radiology and neurodevelopmental treatment
Security	Cybersecurity and data analytics

Source: Singapore Management University (2016)

As one of the key stakeholders, educational providers must ensure that the students enrolled in the evolving curriculums for a digital economy must be trained for a cluster of related occupations and industries instead of a single occupation. Industries inputs are crucial (Business Times, 27 May 2017). Ideally students should also be placed on work-study programmes. There is a need to move from academic learning for the sake of credentials towards skills needed in the work place.

The educational landscape will become increasingly diversified and in the new landscape, the benchmarking of accepted standards and credentialing for on-line and other self-taught courses will need to be developed and accepted by all stakeholders.

Technical and vocational education should go beyond hard and technical skills alone. There is an urgent need for curricula to embed a multidisciplinary and integrated approach that provides trainees with core elements laying the spectrum of hard and soft skills needed in the work place. These would include, creativity, problem solving, critical thinking, communication and the ability to function in teams and decision making (Asian Development Bank, 2015).

In the digital economy, skills challenges remain in the ICT industry. First, mid-career PMETs are reluctant to move into the industry due to pay cuts and the learning curves are steep. Second, IHLs are incorporating more specialised technical skills into their ICT curricula, but are not introducing relevant courses to meet industry needs fast enough. Third, wage depression in certain lower level programming jobs are due partly to the widespread hiring of foreign workers. This may hinder initiatives such as the ELP apprenticeship programme for polytechnic and vocational school graduates (Singapore Management University, 2016).

In specific industry sectors, such as retail, as traditional retail moves into e-commerce, positions in the evolving retail sector demands skills sets, such as experience, and user interface designers, cybersecurity experts, project professionals with digital transformation knowledge and digital marketers (Business Times, 20 January 2017).

Specific Recommendations

First, the links between industry and IHLs should be strengthened further. For example, amalgamating the manpower and educational ministries would support the paradigm shift to encompass the human capital trends that are already emerging. The process of education is no longer linear, but a continuous cyclical process that follows industry cycles. Front loading skills onto students only helps to an extent if the core skills are resilient over time and able to be transferred to other sectors. If the same ministry oversees the supply and demand for labour, better coordination and timely government intervention would make for better policy formulation and implementation. This could mean closer coordination between the Ministries of Education and Manpower under the same coordinating senior minister or alternatively a combination of the two ministries.

Second, the ageing population and workforce requires greater government coordination to sustain mature workers in gainful employment. A ministry of ageing may be required to cover a gamut of concerns from manpower to healthcare. This proposed ministry should have a strategic department or division on mature workers that is linked to the new educational and manpower ministry to mitigate or reduce the incidence of ageism in employment. This would also enable both ministries to work in a more coordinated manner to resolve converging challenges, such as the large displacement of mature PMETs (professional, managers, engineers and technicians) from certain industries, including professional services favoured by the local population.

Third, the lack of infocomm workers in critical areas, such as data analytics and cybersecurity, is a key impediment. In this regard, the MCI should establish a department or division that works closely with the amalgamated Ministry of Manpower and Education and the Ministry of Ageing to shape future human capital and displaced human capital for the needs of this vital infocomm sector. Without critical infocomm human capital, the timeline for digitalisation of Singapore's economy will be further delayed.

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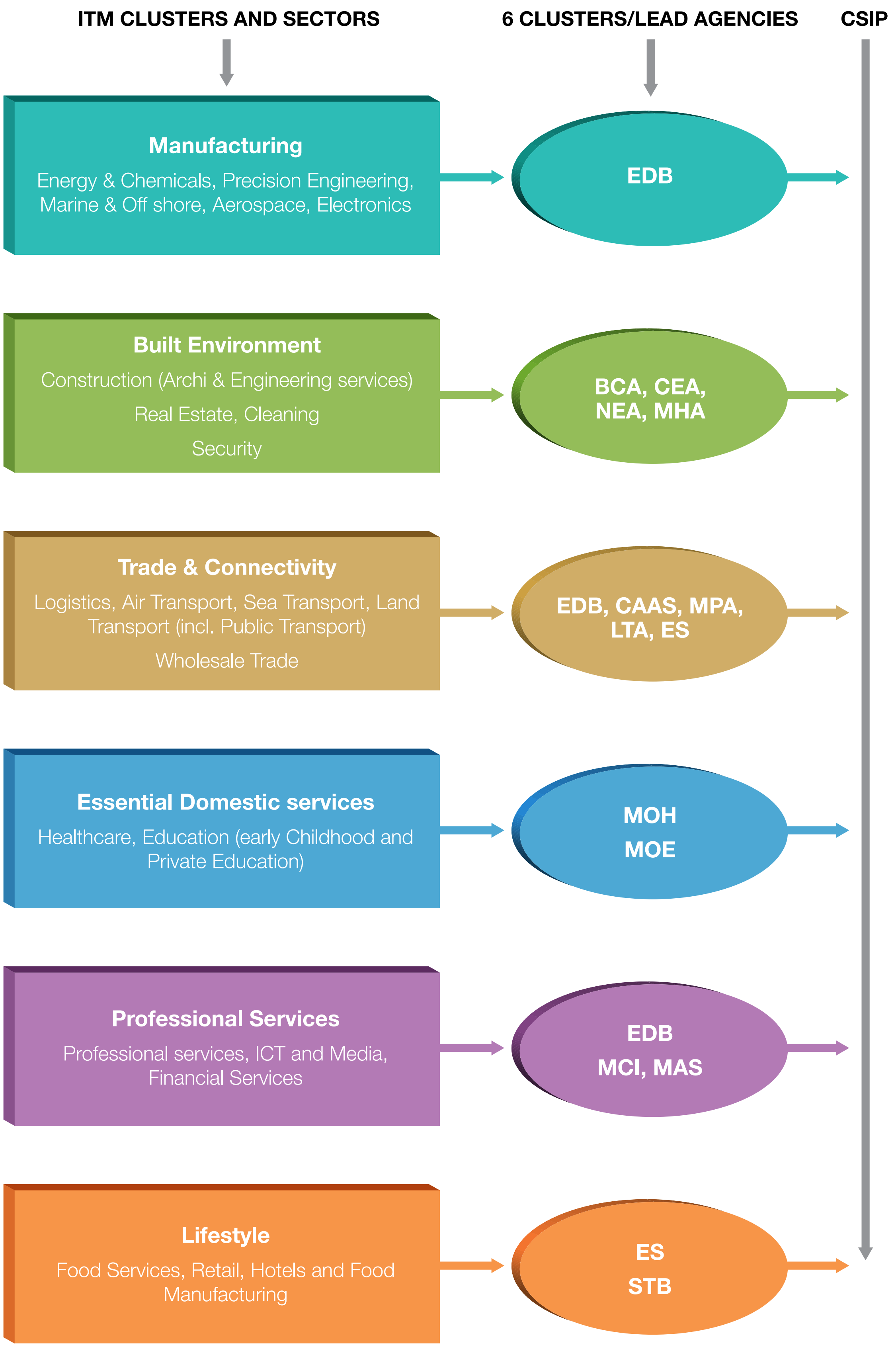
Annex

ITM Operational Diagram



Index for Acronyms

S/No	Lead Agency	Acronym
1	Building and Construction Authority	BCA
2	Civil Aviation Authority of Singapore	CAAS
3	Council for Estates Agency	CEA
4	Council for Skills, Innovation and Productivity	CSIP
5	Economic and Development Board	EDB
6	Enterprise Singapore*	ES
7	Land Transport Authority	LTA
8	Maritime Post Authority	MPA
9	Ministry of Communications and Information	MCI
10	Ministry of Education	MOE
11	Ministry of Health	MOH
12	Ministry of Home Affairs	MHA
13	Monetary Authority of Singapore	MAS
14	National Environment Agency	NEA
15	Singapore Tourism Board	STB

** Enterprise Singapore (ES) is a merger between the former agencies of International Enterprises Singapore (IES) and SPRING.*

CHAPTER 7

Digital Transformation in the 21st Century: Implications and Policy

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Digital Transformation in the 21st Century: Implications and Policy

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Introduction

The future of work is uncertain. Compared with previous industrial revolutions, in which technologies took decades to be fully adopted by industry and incorporated into daily work, the adoption of digital automation is expected to be much faster and more intense. The job market will probably experience dislocation, resulting in chronic gaps in supply and demand for the workforce. Unskilled and routine jobs with repetitive production processes are vulnerable to automation, resulting in unemployment for low-skilled workers. Our education system, which is based on a standardized learning pathway designed to produce a large pool of workers to support traditional industries, is not ready to provide the talent needed for the new types of jobs created by digital automation. Such a dislocation of the job market will generate stress in society as a whole if the transition is left to market forces. Governments have the responsibility and the means to facilitate a smooth transition by providing support to the displaced workforce and nurturing the talent needed to sustain the economic trajectory of society.

As was generally concluded in the earlier chapters of this book, such a transition is inevitable. This presents a wide spectrum of challenges to Asia Pacific countries, which are at different stages of economic development and feature diverse social demographic compositions. In this chapter, we provide policy recommendations after first establishing the premises on which we base them. The premises help to identify the gaps between government policies and the needs of society in the age of digital automation.

Workforce transition is not likely to happen in discrete stages, but instead will involve a continuous shift from one equilibrium to another. It will be shaped by both exogenous and endogenous factors, some of which are in the domain of policy and legislation even as others are beyond the control of policy makers. Governments will play a vital role in modulating the transition of workforce equilibrium to minimize the dislocation of society while maintaining sustainable economic growth.

Exponential Growth of Computing Power, Storage, and Communication Capacity

The first premise concerns the long-term trend of technological advancement. Digital automation is driven by the rapid advancement of information technology (IT). The golden standard for gauging the rate of technological advancement is Moore's Law, which states that the performance of computers doubles every 18 to 24 months. The result is an exponential improvement of computing performance, storage, and communication capacity over time. Although some observations indicate that the growth rate predicted by Moore's Law has flattened in recent years, a sharp decline is still unlikely. Thus the economic potential of automating human tasks with computers will continue to grow at an ever-increasing pace.

The rapid pace of technological advancement is fueled by the positive externality of digital automation, which is driven by algorithms and realized as software solutions. Software features tremendous inherent scalability and almost zero marginal cost for reproduction. Automation solutions can be made available over the Cloud to anyone connected to the Internet. The immense scalability and reach of software compared to physical products significantly reduces the cost of distribution and adoption across national boundaries. The world can benefit quickly from innovations, because software can be instantaneously deployed over a large geographical region. For example, IBM's Watson-based medical diagnosis system can be deployed in developing countries that lack or cannot afford healthcare professionals. The system can thus have a great positive impact on humanity.

For the same reasons, software solutions could lead to a natural monopoly or winner-take-all situation. For example, two major mobile device operating systems - IOS and Android, dominate the global market share. On the positive side, the standardization of technology, either formal or de facto, reduces the cost of product development, enabling a larger population of developers to participate in the ecosystem created by digital automation. The consequences are new jobs and the injection of new energy into the economy. However, high concentration in an industry will stifle innovation, as new entrants cannot compete with incumbents. For example, using two commonly adopted concentration indices, the Hirschman Herfindahl Index and the Four-Firm Concentration Ratio, a recent report indicates a strongly imbalanced oligopoly in which four major operating systems control 99% of the market and the dominant operating system, Android, is installed on over 80% of new devices worldwide (Naldi, 2016).

Changes in Lifestyle and Work Culture

The second premise is that the general population will experience a change in lifestyle. As was established in previous chapters, many jobs will be redefined. As Chapter 4 showed, work conditions will be more flexible and customizable; people will work flexible hours or work remotely. As manual work is gradually replaced by better, cheaper, and more efficient technologies, time previously spent at work can be allocated to other activities. Automation and artificial intelligence (AI) will have a significant impact beyond the workplace, reshaping the way we live and our cultural values. Home automation will make managing household tasks much easier, as robots can perform general repetitive tasks more cost-effectively than humans. When people spend fewer hours on housework, they can allocate more time to leisure and other activities outside the office or home.

A change in lifestyle toward fewer working hours may translate into more opportunities for consumer spending, which is largely determined by disposable income. Automation will raise the salaries of highly skilled workers, which will increase spending power and demand. When manufacturers increase supply to meet demand, more jobs will be created, thus triggering a virtuous cycle leading to economic expansion.

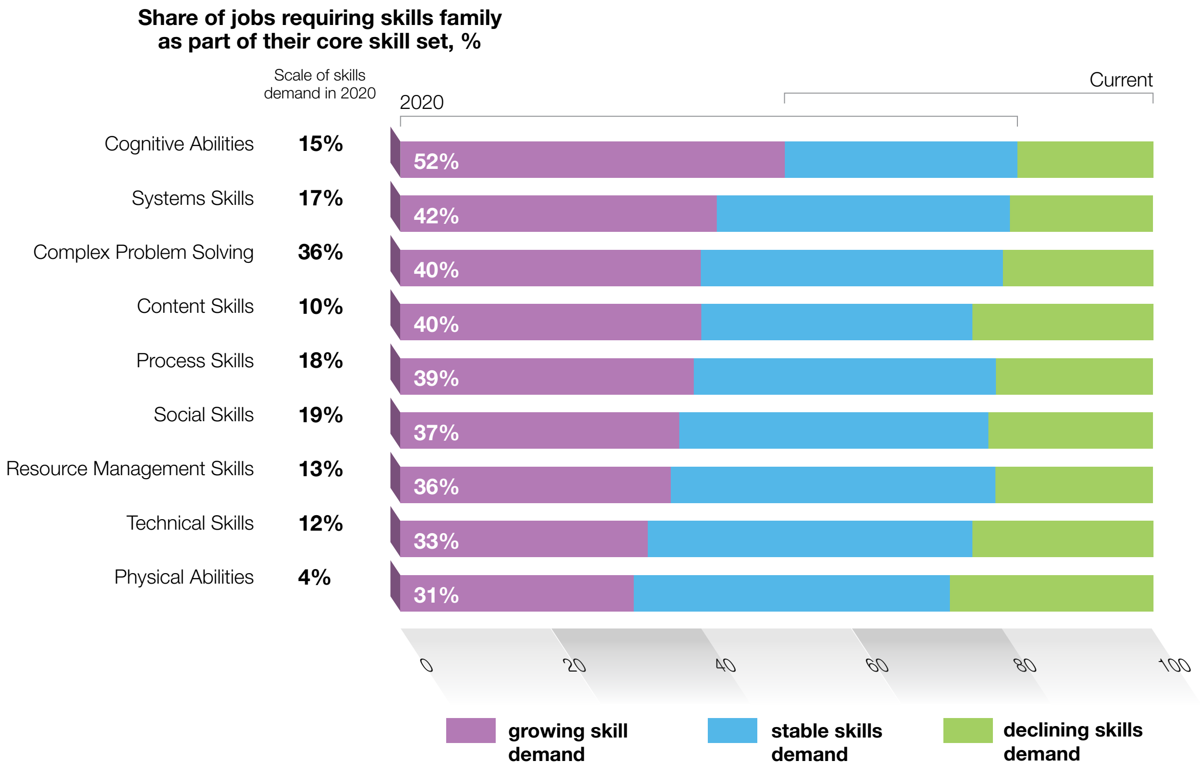
That said, this prediction assumes that overall demand will not be significantly weakened by unemployment among low-skilled workers as a result of automation. Unless this situation is dealt with, low-skilled workers will suffer the most, as they are most susceptible to displacement, and the situation will widen the income gap. Changes in lifestyle will have an impact on workers' standard of living, and the consequences will vary across the skill spectrum of the workforce.

Job Skill Shifts

The third premise is that changes in necessary competencies and skill sets are imminent. Job displacement is one of the most discussed topics in relation to automation. Although low-skilled jobs are vulnerable to automation, other types of jobs are less displaceable. As evidenced in previous industrial revolutions, new categories of jobs will be created as the economy embraces automation. The job market will undergo continual adjustment in search of a new equilibrium with the best man-to-machine combination. Compared with previous industrial revolutions, however, the adjustment will take place at a much faster pace.

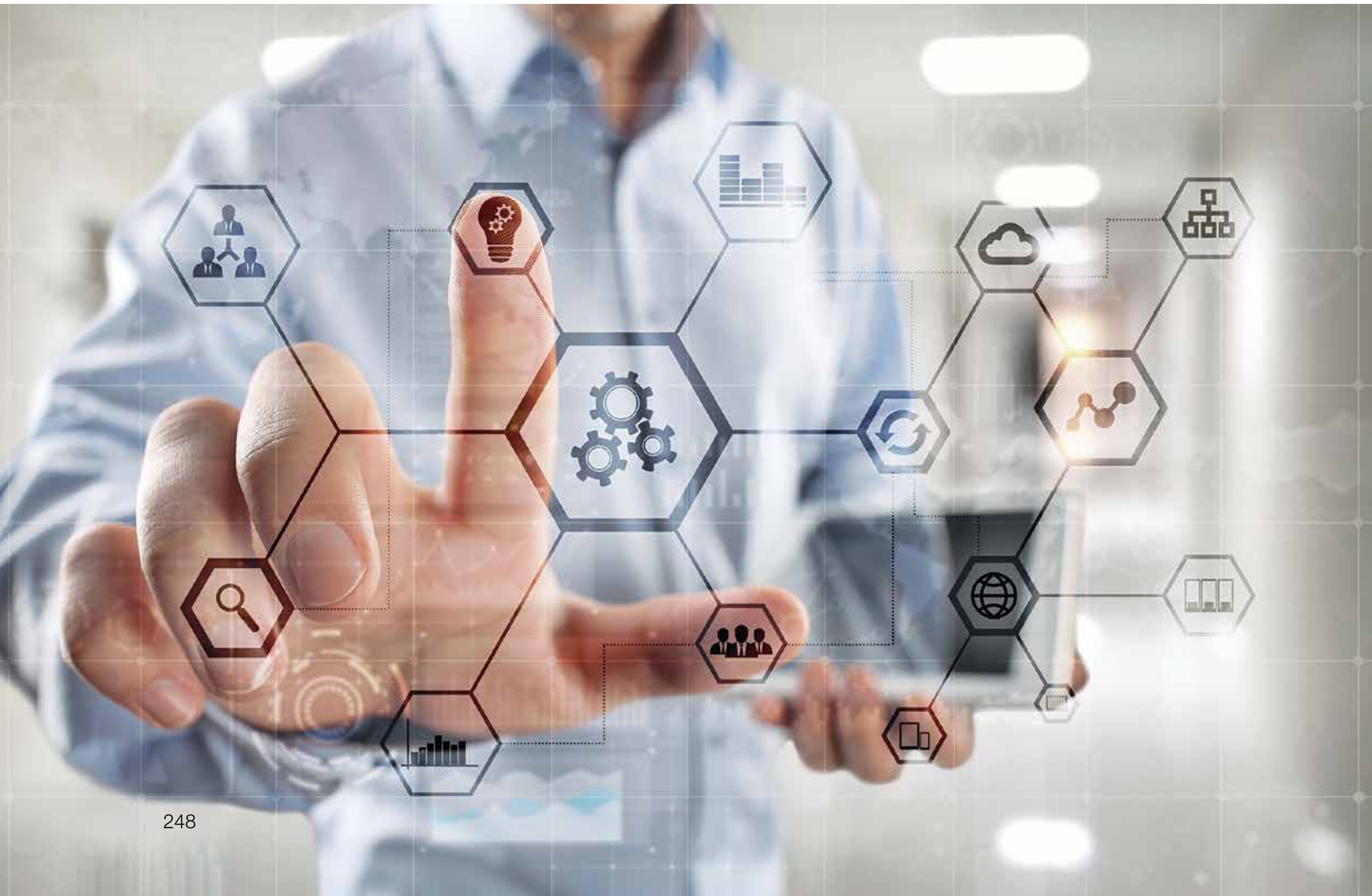
A 2016 report published by the World Economic Forum predicted job losses due to disruptive labor market changes from 2015 to 2020 (Figure 1) and argued that workers should focus on fostering skills around critical thinking and creativity to outperform robots (WEF, 2016). Most automated tasks will involve physical and manual labor and basic cognitive skills. Jobs that require social, emotional, and higher cognitive skills are unlikely to be replaced by machines in the short and medium term, so roles that require these skills will still be assumed by humans. At the same time, new jobs that require digital skills and advanced technological knowledge will emerge. As a result, there will be a discrepancy between the skills of current workers and those working with robots in an automated environment.

Figure 1: Change in demand for core work-related skills, 2015-2020, all industries



Source: World Economic Forum (2016). The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution.

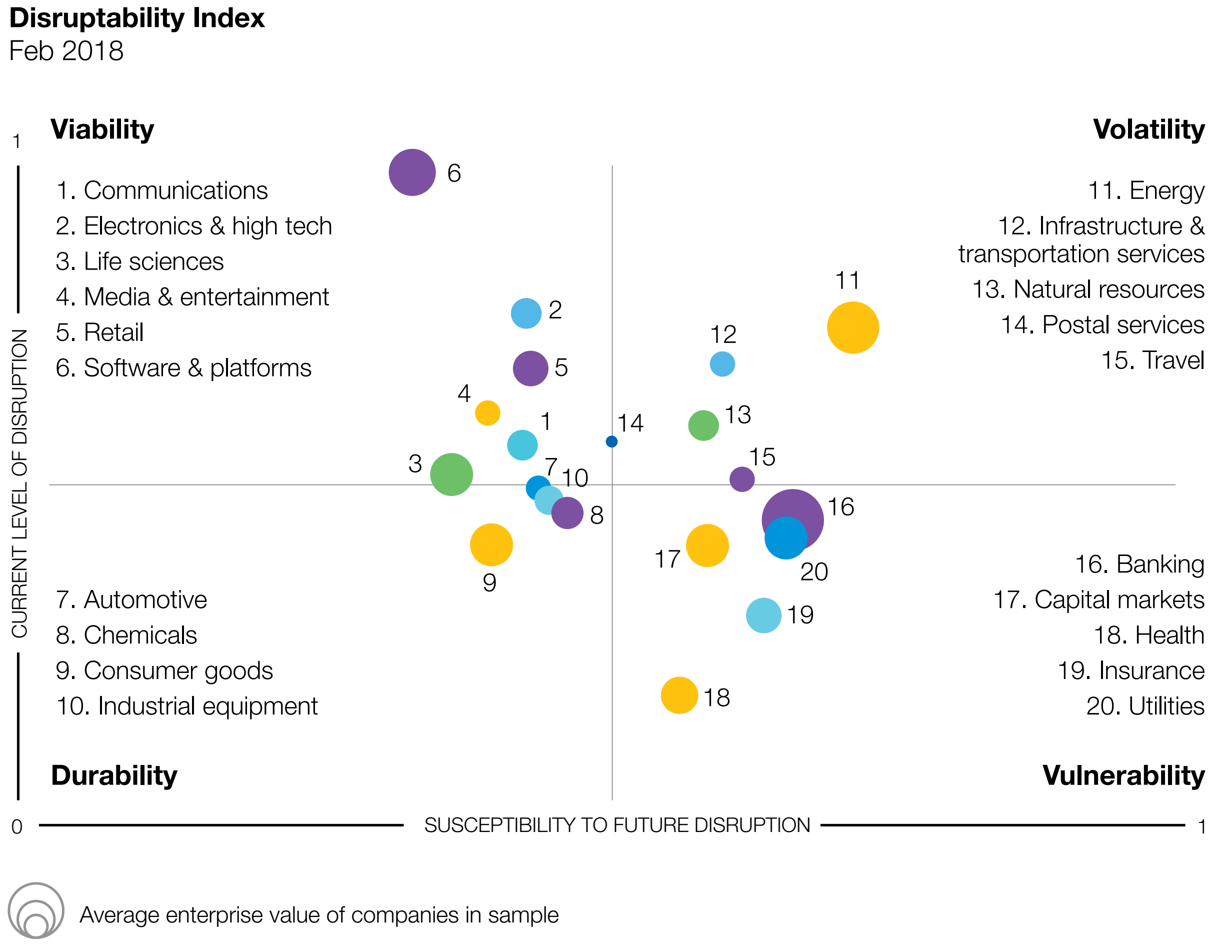
Workers who do not possess the required competences to take up these new jobs are more likely to be displaced, receive lower wages, and experience unemployment. However, the demand for high-skilled workers will increase, driving wages for this part of the population. An unprepared labor market will result in a society unable to achieve full productivity growth due to a lack of high-skilled workers and an excess of low-skilled workers. The result will be increased income disparity between these two groups of workers.



The Impact of Digital Automation Varies Across Industries

The fourth premise is that at a macro level, the impact of digital automation and the disruptions it causes will vary across industries. Accenture analyzed over 3,200 companies across 98 industry segments to create the Disruptability Index (Figure 2), which gauges the current level of disruption and susceptibility to future disruption of 20 industries. The index results suggest that different emphases are required in the strategic actions of different types of business through each phase of disruption (Abbosh, Moore & Moussavi, 2018).

Figure 2: Disruptability Index 2018



Source: Abbosh, O., Moore, M., Moussavi, B. (2018). Disruption Need Not Be an Enigma. Accenture.

According to Digital Transformation: Insight into Getting It Right, a report by the International Data Corporation (IDC), 65.6% of corporations in Asia Pacific reported that the three major drivers for digital transformation are (1) increasing employee productivity, (2) supporting new products and revenue streams, and (3) delivering better customer experience. Whether these firms' goal is revenue growth, cost reduction, or improved business operations, recruiting and retaining talent with the right skills are necessary for them to reap the benefits of digital transformation (IDC, 2018). However, as pointed out in the report, insufficient skills and training were seen as the biggest barrier. In a 2016 study conducted by MIT Sloan Management Review and Deloitte Digital, 87% of the business executives surveyed indicated that their industries will be disrupted by digital technologies to a great or moderate extent, but only 44% of them agreed that their companies were adequately prepared for these disruptions (Kane, 2018).

It has been predicted that by 2025, technologies such as mobile commerce, location-based services, the Internet of Things (IoT), cloud technology, 3D printing, and advanced robotics may lead to 30% gross domestic product (GDP) growth in Southeast Asian economies alone, and the impact on GDP of disruptive technologies in some of the region's biggest economic zones is expected to be significant (Canton, 2015). As shown in Figure 3, although the Asia Pacific region has an average digital readiness score higher than the global average (Malladi, 2017), not every country within the region is equally ready, making some more vulnerable to technological disruptions.

Figure 3: Digital readiness scores of selected countries in the Asia Pacific region

Country	Score	Stage	Country	Score	Stage
Australia	17.34	Amplify	New Zealand	16.90	Amplify
Bangladesh	8.01	Activate	Pakistan	8.58	Activate
Myanmar	8.41	Activate	Papua New Guinea	7.80	Activate
Cambodia	8.60	Activate	Philippines	12.15	Accelerate
China	13.64	Accelerate	Singapore	18.30	Amplify
India	10.54	Accelerate	South Korea	17.50	Amplify
Indonesia	11.73	Accelerate	Sri Lanka	11.56	Accelerate
Japan	17.33	Amplify	Thailand	12.53	Accelerate
Malaysia	15.19	Amplify	Vietnam	12.56	Accelerate
Nepal	9.61	Activate			

"Activate": beginning of the digital journey; primarily benefiting from interventions focused on improvements in basic human needs and human capital development, especially growing foundational IT knowledge.

"Accelerate": middle stage of the digital journey; mostly benefiting from human capital development, basic human needs improvements, and advancements in the ease of doing business in the country.

"Amplify": highest stage of digital readiness; mostly benefiting from human capital development, especially a focus on specialized, emerging technology skills.

Source: Cisco (2018). Country Digital Readiness White Paper.

It is important for policy makers to understand the nature of disruption and recognize it as an opportunity, and at the same time recognize that the transition and magnitude of disruption vary significantly across industries. Without adequate knowledge and preparation, the economy as a whole will not be able to cope with these changes. Firms lacking the knowledge necessary for automation and the organizational structures and business practices needed for digital transformation will be driven out of business. Whether a society is well-prepared for technological disruption will dictate the trajectory of its economic growth. Again, the government can play an important role in mitigating the risk of disruption and creating a supportive economic infrastructure to facilitate a smooth digital transformation.

Impact on Manufacturing Productivity and Global Competitiveness

The fifth premise concerns the rapid development of the technology sector in the Asia Pacific region. The technology sector has changed the innovation ecosystem in the economy, introducing new techniques of production and business models. Technology trends affect many industries, and one that has a strong appetite for technology is manufacturing. According to PwC's 2018 Global Digital Operations Study, the contribution of digitization and smart automation to global GDP is expected to reach 14% by 2030, which is equivalent to approximately US$15 trillion in current value (PwC, 2018). The increasing use of machines and industrial robots helps firms to achieve greater economies of scale and productivity. Automation helps manufacturers to lower their operating costs and increase output, and makes them less reliant on labor input. Nonetheless, skilled labor will be in high demand for designing, installing, and managing automated facilities. The acute shortage of talent in this area will boost salaries, contributing to the aforementioned skill shift phenomenon that will drive changes in labor mobility, employment, and income.

Among manufacturing companies benefiting worldwide from automation and intelligent manufacturing systems, the Asia Pacific region is a global leader. That said, despite the beneficial effect of automation on productivity, only a small proportion of manufacturing companies have established a digital infrastructure. Many manufacturers are still in the experimental stage (PwC, 2018). In addition, even though companies of all sizes can take advantage of new, disruptive technologies, large corporations are more capable of adopting new technological trends, whereas small and medium-sized firms (SMEs) may lack financial resources for new equipment and tools to compete with larger manufacturers. While automation can increase overall productivity, it may also drive out small businesses, which will have negative impacts on the economy and its ecosystem. Another issue is that SMEs may ignore technological innovation despite its long-term potential if labor costs remain low.

As pioneers in adopting production automation, Asia Pacific countries are not only inspiring entrepreneurship within the region, but also globally reshaping the digital landscape. The value of economic growth is not merely indicated by GDP; the challenges and complexities encountered by economies also count. New models of human-centric economic progress have been gaining ground, which require countries to closely monitor the factors that determine their competitiveness, based on the sustainable and equitable welfare of their populations (WEF, 2017).

Psychological and Ethical Issues Arising from Digital Automation

The last premise is that working with machines and robots not only induces changes in the work environment, but also has psychological effects on workers. Examples include fear of job loss due to automation, concerns about safety arising from machine operation, and ethical issues resulting from working with robots. Unlike workers today, future workers will be less motivated by income alone and more inclined to have a different set of values that stresses work-life balance, including aspects of life such as health, relationships, family, and creativity.

Machines using AI have gradually reshaped our lives. Virtual assistants like Siri and Alexa, self-driving vehicles such as Domino's pizza delivery car and Tesla's Autopilot, and the use of chatbots and machine learning by financial institutions are just a few examples of how these technologies are changing the way we live. Although the efficiency and effectiveness of automation and robots for businesses can be measured easily by outcomes such as costs, outputs, and profits, the social and psychological effects of robots on humans are difficult to quantify (Marselis, 2016). People's feelings toward robotics and AI will change as these technologies are widely adopted in our everyday lives.

The reliance on automation has given rise to issues including loss of data privacy, decision biases that reinforce discrimination and injustice, and challenges in attributing responsibility, among many others. Government policies and regulations are pivotal in addressing these issues and concerns.

Policy Recommendations

The premises outlined in the previous sections offer an overarching framework for our policy analysis and recommendations concerning digital automation. These premises can be summarized as follows.

- The exponential growth, standardization, and adoption of IT will continue worldwide.
- Changes in the lifestyle of the working population will continue to shape the social and cultural landscape of Asia Pacific countries, and a new set of cultural and societal values relating to work will emerge.
- A skill shift in the labor market will lead to income disparity between workers with high and low skill levels.
- The impact of automation will vary across industries. Businesses, small enterprises in particular, that lack the talent and financial resources to adopt new technologies will be vulnerable in the process of digital transformation. They may be driven out of the market, which will result in unemployment and a less diverse and innovative economy.
- Manufacturing is a major sector of many Asia Pacific economies. Its transition from a labor-intensive to a technology-driven base can be better facilitated by strengthening the technology sector.
- The psychological effects of interactions with robots will play a role in how humans respond to automation, which in turn will affect the development of work, cultural, and social values.

We now turn to policy recommendations based on these six premises.

Science, Technology, Engineering, and Mathematics (STEM) Education

It is important to ensure that our younger generation possesses a high degree of digital literacy. It is recommended that students be exposed to digital tools at an early age and that IT and coding be included as core subjects in the K-12 curriculum. The objective is to arouse the interest and curiosity of students through a rich and stimulating learning experience, and to nurture their ability to work with digital tools to solve real world problems. Furthermore, as students progress to their senior years, they will see for themselves the progress of technology over time. Programming languages and tools that were popular a few years ago are now being replaced by more advanced tools and platforms. This experience will plant the seeds for continuous learning in later stages of life. It will also reinforce the belief that new tools are constantly developing to help solve problems, and that self-learning is a critical competency for the future workforce. In 2014, the UK became the first country to introduce coding classes to primary schools. In Asia, Singapore and Hong Kong include coding as an optional subject in the primary school curriculum. Coding boot camps have also become popular as co-curricular activities in many secondary schools worldwide.

In terms of policy recommendations, education ministries should include STEM content in the curriculum and more resources should be devoted to training teachers in this area. Furthermore, teaching development grants promoting STEM education should be provided to schools as an incentive to encourage innovative teaching. Examples of best practice should be shared among schools and incorporated into the national curriculum. Universities should be encouraged to work with schools to co-develop programs to increase interest among high school students. These may include science camps, innovation competitions, co-developed STEM curriculums, and education degrees for STEM teachers. Female students in Asia may shy away from STEM education even when they are interested and capable of excelling in science subjects. This gender imbalance is not unique to Asia, but Asian culture presents more challenges to breaking away from prevailing social norms rooted in centuries-long traditions. Attracting more female talent to STEM should be a priority in overall STEM education policy making.

A related policy is the development of accelerated STEM pathways allowing gifted students to fully unleash their talents. Talented students should not be constrained by standardized curricula that are paced according to the average students' abilities. Gifted education should be a key component of a STEM education policy, with institutions established to cater to the needs of gifted students and provide them with support and opportunities to realize their potential.

Soft Skills Development and Continuous Curriculum Reform

Although STEM knowledge is essential for responding to the challenges and opportunities of digital automation, it should not overshadow creativity, communication skills, problem solving skills, and resilience. To prepare students for the future job market, it is important that they acquire both technical and soft skills. In a study conducted by the Economist Intelligence Unit (EIU), 79% of the surveyed educators believed that soft skills need to be developed alongside foundational literacies (EIU, 2018). As routine and manual tasks are replaced by machines and automated tools, creativity, self-reflection, empathy, care for others, resilience, and the ability to communicate clearly can only become more important as the foundation of future jobs. As such, curricula in primary and secondary schools should be revised to attach greater importance to these qualities as learning objectives and outcomes. A more flexible learning pathway should be provided to allow students to develop their interests and skills, replacing the current curriculum, which is relatively universal. Such a flexible approach is especially important for students who have demonstrated gifts in areas such as music, mathematics, science, coding, performance, and sports. The traditional curriculum does not cater to the needs of these students. The EIU study also found that many standard teaching practices are not effective in helping students acquire skills needed by the future workforce; therefore, new pedagogies are required to equip students with “workplace-ready” skills in the new era of automation.

In many Asia Pacific countries, primary and secondary education is highly regulated. Many government-funded schools must follow a standard curriculum aimed at preparation for university entrance examinations. Furthermore, to demonstrate accountability and impartiality in the use of public funds, funding is based on rigid criteria rather than on encouraging innovation and flexibility in the learning process. Learning becomes examination-driven, and there is little flexibility for schools to cope with the different learning capabilities of students, not to mention providing different pathways for students to study the same subject.

The main challenge is a lack of funding and qualified teachers. The development of the abovementioned core competencies is best achieved through experiential learning, which requires considerable investment in teaching staff and providing learning opportunities. It is not feasible for a country to revamp its education system overnight, due to economic and political constraints. However, it is possible for the government to create a more diversified education system, offering more options for curricula and study pathways for students. In countries with a highly regulated school system, the government should consider relaxing regulations and giving schools more flexibility in terms of pedagogical approach and curriculum structure. Furthermore, the government should be more open to allowing publicly funded schools to adopt international education curricula (e.g. the International Baccalaureate (IB) curriculum) to introduce innovations to the ecosystem. If a national curriculum is maintained, it should be regularly reviewed and revised to meet the needs of society.

Evidence shows that education reforms can still happen in developing countries where the government may be financially constrained. According to the World Economic Forum, emerging markets have remarkable potential to develop innovative education systems. Despite the lack of resources, novel curricula have been developed; some have been jointly designed by schools and businesses to ensure that graduates are equipped with relevant skills to contribute to the job market and hence the economy.

Investing in Teachers

Teachers may not be proficient in technology, as they are not digital natives like their students. Therefore, more support for teachers and their professional development is necessary, especially among those teaching STEM and experiential learning subjects. It is also essential to develop regular professional development training programs together with the industry and provide training opportunities enabling educators to develop new skills and stay abreast of market needs. As a result, teachers will be better able to develop appropriate pedagogies and teaching materials in response to changing educational demands.

Increasing the salaries of teachers is vital to attract and retain qualified candidates. The United Nations Educational, Scientific and Cultural Organization (UNESCO) studied the teaching profession in eight countries in the Asia Pacific region and found that teachers' salaries were on the low side; it advised increasing them to levels "commensurate to what the jobs require and… comparable with other professions that require similar qualifications" (UNESCO, 2015). The same report also pointed out that the workloads for teachers are unrealistic, as they need to perform supervisory and administrative duties and counselling in addition to teaching, preparation, and marking. Offering attractive salary packages in recognition of teachers' responsibilities and workloads may boost motivation and encourage talented individuals to join the profession, thus increasing the supply of teachers.

Financial support from the government is critical. Governments should budget for teachers to engage in continuous learning. Approaches could include topping up the regular education budget to cover teacher retraining or setting up an endowment fund to provide ongoing support independent of the recurrent budget which could fluctuate over time. Furthermore, governments should foster closer collaboration between schools and universities on STEM education. As mentioned earlier, students in K-12 should be exposed to science and coding earlier. They should be encouraged to use the facilities and instruments at universities to gain more knowledge about these subjects. STEM teachers could also be given sabbatical leave to work in universities to refresh themselves intellectually and engage in research projects, whose findings they can bring back to their schools. Again, financial support from the government is critical.

To supplement the existing STEM teacher pool, schools could engage retired professionals who have a passion for teaching and nurturing the next generation, especially in technical areas such as engineering and IT. They can bring real-life issues and problems (and their resolutions) to the classroom to further enrich the learning experience for students. Engaging professionals in the classroom is a common practice in university education worldwide, and has proven to be very effective and well received by students, particularly in business, law, medical, and engineering schools. It is not uncommon for academics and professionals to co-teach a course to provide balanced coverage of intellectual and practical content. Engaging experienced professionals in the high school sector will increase the supply of teachers to meet the rising demand for STEM education and experiential learning. As the K-12 curriculum and teacher qualifications are highly regulated in some Asian countries, governments should consider relaxing the qualification requirements to facilitate cooperation between educational institutions and industry.

University Education

A typical university education is a 4-year degree with a highly structured curriculum. Public universities are also highly regulated in many Asia Pacific countries in terms of student enrollment, tuition, and curriculum. Although new subjects and programs are added (and outdated ones removed) to reflect the changing demands of society, the way students learn has not changed significantly for decades. Indeed, the method of delivering content through lectures and tutorials, and the division of content into a linear sequence of courses over a semester or quarter, has remained the same for almost a century.

The rising cost of university education and the stagnant salaries of graduates over the last two decades in many developed countries have raised concerns about the relevance of university education. The rapid pace of economic change due to digital automation has cast doubt on whether universities are producing the talents needed by society. The worldwide rise of corporate universities, which are more responsive than traditional universities to market needs for nurturing talent, reflects the challenges facing traditional universities, such as scalability and adaptability.

A number of initiatives offer novel learning experiences that are very different from traditional degree programs. One pilot education program that breaks away from the traditional university curriculum is the Minerva School. Minerva aims to nurture young talent by fostering essential skills and cross-disciplinary knowledge. Students start with learning modules that focus on problem framing and solving, thinking, and communicating effectively. They then choose from a set of five majors in arts and humanities, business, computational sciences, natural sciences, and social sciences. Students are paired with academic advisors to offer them advice on academic development in their school and career development upon graduation. The learning-centric teaching approach used by Minerva has proven to be at least as effective as the approach taken at traditional institutions. Minerva freshmen's average scores in the Collegiate Learning Assessment (CLA+), a standardized test that assesses critical thinking, problem-solving, and written expression to evaluate what students have learned during a single academic year, were higher than those from senior graduating classes at every other university and college at which the same test was administered (Kosslyn, 2017). A distinctive feature of the program is the extensive use of digital technology to deliver content and support discussion among geographically dispersed students. The academic curriculum is supplemented by significant experiential learning opportunities in different locations worldwide.

Massive Open Online Courses (MOOCs) delivered over platforms such as Coursera and edX offer a new way to teach and significantly increase program scalability. Some universities have started migrating their face-to-face degree programs to pure online delivery. Notable examples are the online Master's degrees offered by the University of Illinois (Urbana) and the Georgia Institute of Technology. Enrollment size is no longer restricted by classroom capacity, which limits cohort size, but can expand linearly with enrollment. Students enrolled in MOOCs can learn at their own pace, yet attain the same degree credentials. MOOCs still have limitations in terms of providing high-fidelity social interaction between instructors and students, and between students themselves. A new research discipline of learning analytics has emerged to study learners' behavior, performance, and assessment in an online environment. Intelligent chatbots for learning support will be available in the not so distant future, further increasing the viability of MOOCs and their cost-effectiveness. As explained earlier, MOOCs are software artifacts that can scale up significantly at a very low marginal cost.

In terms of university education, governments should encourage universities to adopt new delivery mechanisms to increase the scalability and adaptability of their program offerings. Policy instruments include (1) providing teaching development grants to assist universities to build capacity in online content production and delivery; (2) working with quality assurance agencies to offer accreditation reviews to online programs to ensure their quality is comparable to that of traditional face-to-face programs; (3) fostering academic-industry cooperation, especially in areas facing an acute shortage of talent (e.g. through joint training programs with industry that provide students with industry-specific knowhow, product knowledge, and internship opportunities); and (4) identifying training areas important to national economic development and providing priority funding to universities with programs in these areas.

Retraining the Displaced Workforce

As the impact of automation on the economy unfolds, workers who perform simple and repetitive tasks will probably be displaced. The government should develop a policy that prioritizes retraining the displaced workforce to alleviate the social impact of unemployment. To coordinate the efforts of government branches, a ministerial office should be set up to oversee retraining initiatives. The major roles of the office would be to advise the government on retraining needs, develop resource plans for retraining initiatives, and coordinate with different government branches.

It is of paramount importance for the government to monitor employment trends and the job market. The office should collect data from other government offices regularly with regard to the labor market, migration, tax revenue, social welfare, and company registration and online job portals and professional platforms (e.g. LinkedIn) to collect job market intelligence. It should also refer to the experiences and development trends of other countries to formulate an overall retraining strategy that meets the specific needs of the country. The office should also consider developing a government portal that facilitates job searching and matching and provides advice to displaced workers about opportunities for retraining, roadmaps to attaining professional qualifications for prospective jobs, and available funding support.

Some Asia Pacific countries have a qualification framework that maps education and professional qualifications to a hierarchy of levels. Each qualification is assigned a level in accordance with a set of generic descriptors that specify the outcome standard expected qualifications at each level. In Hong Kong, the qualification framework has seven levels, representing a wide spectrum of knowledge and competence. The outcome standards are arranged into four domains: (a) Knowledge and Intellectual Skills, (b) Processes, (c) Autonomy and Accountability, and (d) Communication, ICT, and Numeracy. Such a qualification framework clearly expresses the competencies required for displaced jobs and emerging ones, which will allow the government and educational institutions to identify retraining needs to equip displaced workers for other jobs. Countries that do not currently have a qualification framework should consider setting one up, so that job seekers, employers, educational institutions and retraining program providers can create competence descriptions of job skills, attainment levels, retraining outcomes, and pathways for professional qualifications.

It is worth noting that not all low-skilled jobs will be displaced. As lifestyles continue to change, with fewer working hours and more time for leisure, more vocational jobs will be created (e.g. hospitality work, home renovation). These may not be high-paid or full-time jobs, but they will provide a level of support to those in career transition. However, they do require competence in certain vocational skills that can be acquired through training. The government should consider setting up vocational training centers focusing on retraining displaced workers for vocations that are in demand. Retraining programs could also be designed jointly by these centers and firms to offer jobs to displaced workers. Upon workers' successful completion of the programs and subsequent employment by firms, the government could refund the program fees to encourage participation.

To encourage continuous learning, financial support could be directly channeled to workers as learning vouchers targeted at areas of expertise that are in high demand. Workers could use these coupons to enroll in certified training at educational institutes. Some Asia Pacific nations offer every citizen a learning voucher to pay for tuition in approved educational programs. This initiative is feasible for countries with relatively small populations (e.g. Singapore). Developing countries may not be able to fully adopt such a policy for all citizens, but could adopt a voucher system for displaced workers.

Retraining the Workforce

In addition to encouraging workers to learn new skills to cope with a digitized environment, employers should be encouraged to provide staff training to maximize the efficiency benefits of automation and the potential of the workforce. In a survey by McKinsey, over 60% of the executives polled stated that 25% of the current workforce will be retrained and replaced by 2023. More than 65% of the participants in the survey regarded retraining the workforce as one of the top priorities of their organizations (McKinsey Global Institute, 2017). If employers do not equip their workers with necessary skills, there will eventually be a gap between the skills that workers possess and the skills that are required. Low-skilled workers will be vulnerable to job loss because they lack the necessary skills to fill other positions if their original jobs are automated. If appropriate training is provided, low-skilled workers will enhance their skill levels, thus boosting the supply of high-skilled workers. Firms that are willing to invest in retraining will also reap the business benefits of higher productivity and lower turnover, which are associated with high employee engagement.

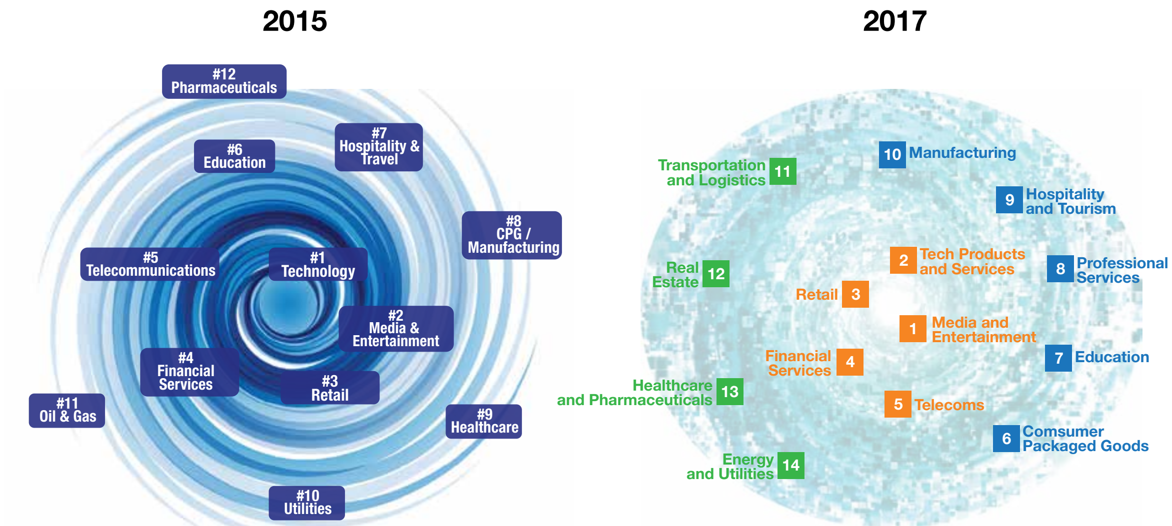
Industry has a strong incentive to upgrade the workforce to benefit from digital automation. As job requirements and responsibilities change, the existing workforce needs to acquire new skills to meet new demands. Large organizations with well-established human resources (HR) offices have the resources to hire HR consultants or experts to perform regular reviews of their human capital and to design training programs in conjunction with external parties or universities. Employees often enroll in part-time training and degree programs at their own expense to enhance their credentials for career advancement. Governments play a less significant role in corporate training in this regard. That said, an effective workforce not only benefits the organization itself, but also contributes to the economy as a whole, as competent workers are less likely to be displaced in the era of digital automation and will continue to contribute to the workforce.

Unlike retraining displaced workers, which requires the government to create a supportive infrastructure of governance bodies and institutions, policy support to retrain the current workforce could take the form of tax incentives and leave provisions. Governments could offer tax incentives to corporations that provide retraining programs for their staff. To be eligible for tax incentives, corporations should ensure that low-skilled workers are included. A more elaborate tax incentive policy is also recommended to provide different incentives for different job categories, with lower level jobs receiving more incentives.

Apart from tax deduction, governments should consider incentives for organizations to grant paid study leave to employers as part of an after-work training plan. This measure can be put forward in conjunction with the tax incentive policy. In industries that are highly regulated (e.g. healthcare, utilities, and banking), regulators can play an active role in facilitating retraining programs across the industry to upgrade specific skills and knowledge in the workforce. For example, bank regulators can require banks to provide training to staff in cybersecurity in view of the increasing threats of cyberattacks. The ministry of health can mandate that hospitals train medical staff in data privacy. These government-led retraining programs aim to increase the awareness of retraining needs and to create a spillover effect to the non-government sector.

As the pace and scale of digital disruption vary greatly across industries, the time required for automation to affect the labor market also varies (Figure 4). As retraining takes time, it is advisable to prepare workers with the most needed skills. This goal can be achieved by identifying sectors with the most labor shortages and surpluses while devising strategies to attract workers with higher risks of displacement to join sectors with labor shortages. Such cross-sector mobility can reduce unemployment as displaced workers find jobs in sectors where labor is most in demand.

Figure 4: Ranking of industries most impacted by automation



Source: Wade (2017). The Digital Vortex in 2017: It's Not a Question of "When." IMD.org.

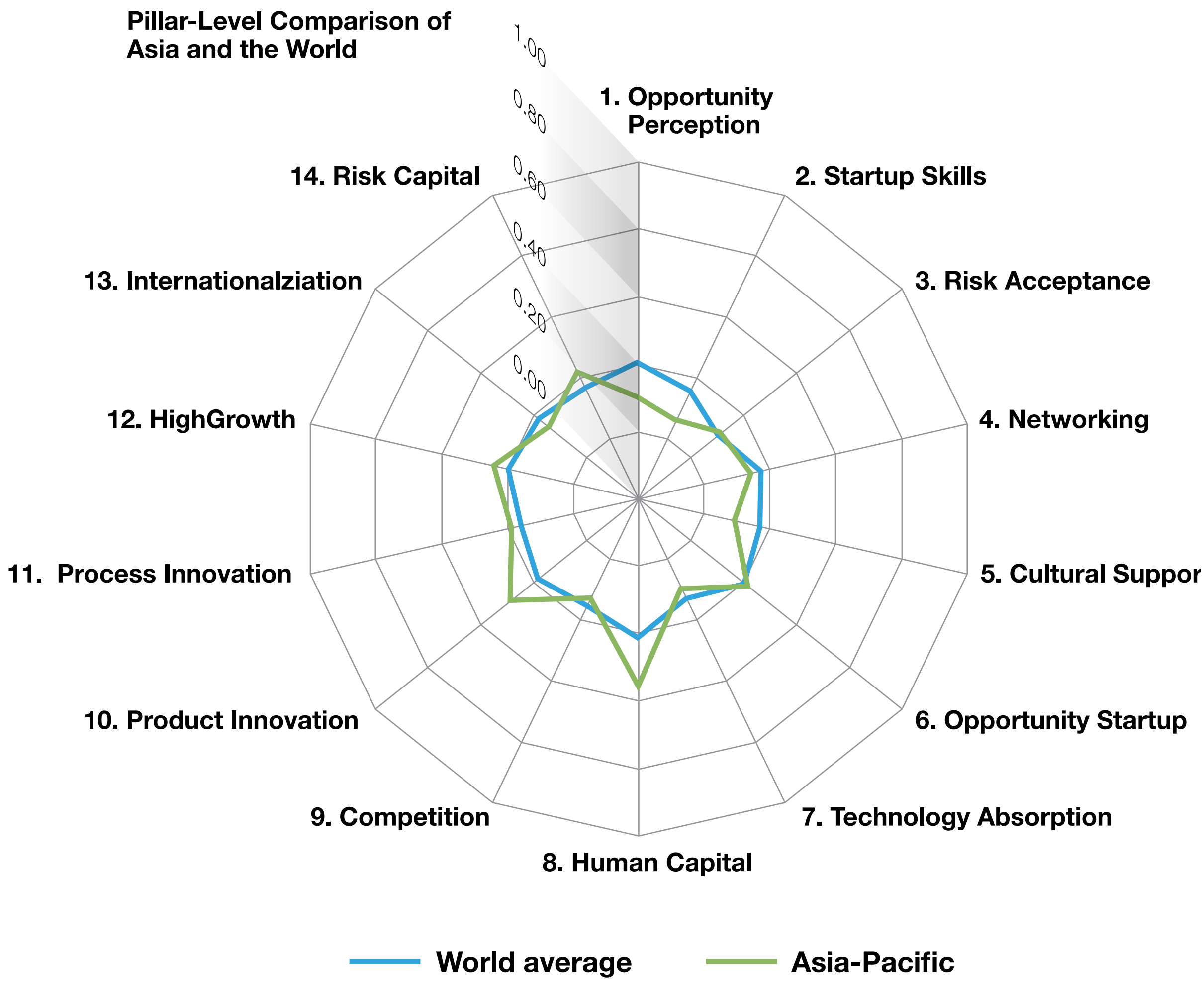
Entrepreneurship and SMEs

It has been estimated that 65% of primary school aged children will end up working in jobs that do not yet exist (WEF, 2016). New business models are needed to combine workers in each skill-level category with technology. Preparing students with the fundamentals of business creation and management and helping them develop an entrepreneurial mindset will benefit the future job market.

Having an entrepreneurial mindset will be an essential quality for workers in the future, when new ideas for streamlining standard business processes and out-of-the-box business solutions will be needed. Future jobs will be more creative and focused on human-to-human and human-machine interactions, even as repetitive and routine jobs are gradually displaced. Changes in the labor market as a result of automation will drive people toward entrepreneurship rather than full-time work. More freelancers and contractors will emerge. There will also be higher mobility and less loyalty to individual companies, as workers will no longer expect job security for life. Entrepreneurs will be needed, as they can create new, smaller companies that provide continued innovation and create jobs.

According to the Global Entrepreneurship Index (GEI) 2017 Report issued by The Global Entrepreneurship and Development Institute, although entrepreneurship does not necessarily make a country rich, improvements in GDP can be brought about by a healthy entrepreneurship ecosystem (Ács et al., 2017). The report also indicates that a good digital ecosystem empowers entrepreneurship. Countries in the Asia Pacific region score lower in the Technology Absorption pillar of GEI scores. The region's average score for Technology Absorption, which reflects the technology intensity of a country's start-up activity combined with the country's capacity for firm-level technology absorption, is only 0.30; in contrast, the average of the top 20 countries in GEI rankings is 0.79. Figure 5 provides a comparison between Asia and the world in the Global Entrepreneurship Index based on the various pillars that contribute to GEI scores.

Figure 5: Global Entrepreneurship Index 2017



Source: Ács, Z., Szerb, L., Lloyd, A. (2017). Global Entrepreneurship Index (GEI) 2017 Report. The Global Entrepreneurship and Development Institute.

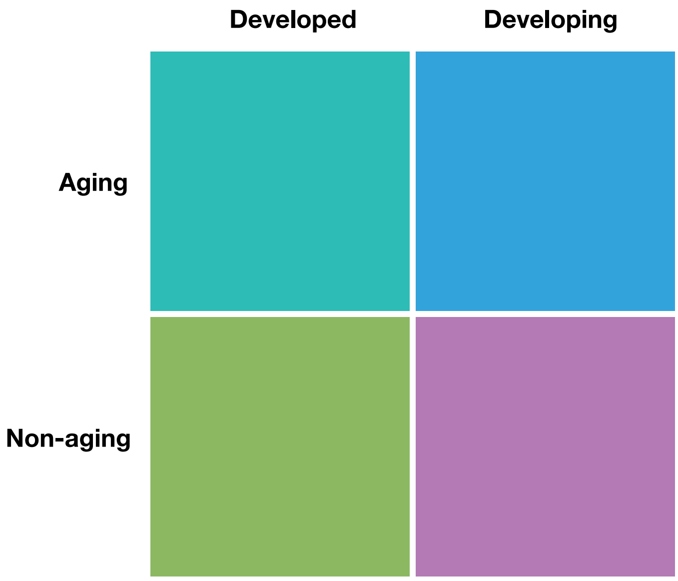
Cultivating an entrepreneurial mindset is critical for Asia Pacific economies, which are dominated by SMEs. SMEs must be more agile and responsive than their large-scale counterparts to market conditions. The appetite to experiment with new ideas, products, and business models and resilience to economic fluctuations determine the success or failure of an SME. Given that SMEs employ most of the population in Asia Pacific economies, governments should establish institutions to help SMEs cope with the job transition challenge resulting from automation. These institutions should focus on downstream technology transfer, trade financing, training, and overseas trade promotion.

Immigration and Mobility of the Workforce

The mobility of the workforce stretches beyond national boundaries. Thus, talent acquisition and retention have become important elements of the national plans of many countries. To moderate the impact of digital automation on the workforce, policies for talent acquisition and immigration need to be jointly developed at the national level.

Asia Pacific countries vary considerably in terms of their stage of economic development, population, financial and natural resources, and demographics. To provide a high-level analysis of the different situations facing countries in the region, countries can be classified using a two-by-two matrix (Figure 6): whether a given country is an aging society, and whether it is a developing or developed country.

Figure 6: Two-by-two classification of countries



In aging developed countries, automation will displace white-collar office workers such as bank tellers, phone operators, and executive assistants. Many middle-aged and older workers are unlikely to rejoin the workforce in positions resembling their previous jobs. Employers would rather invest in training young workers for the new jobs brought about by automation. Younger workers are more technology-savvy and more adaptive to a technology-driven workplace. As elderly workers leave the workforce, there will be an increased burden on the younger working population, which will lead to longer working hours and health issues. Overall economic demand will drop as members of the displaced and aged population hang on to their pensions and reduce their spending. For example, the unemployment wave in Japan in 2009 caused the core consumer price to drop by a record 1.7% in just 6 months.

In the case of non-aging developed countries, there will be an overall decline in the quality of life of the working population if massive unemployment occurs. When the population is relatively young and citizens do not have a stable or high income, their spending power will plummet. The situation will be similar in aging developed countries. However, because countries in this category have a younger and more educated population, the adverse impact will be temporary, as displaced young workers can be retrained.

For aging developing countries in Asia Pacific, manufacturing and agriculture are the two industries supporting the majority of the working population. Most jobs in these industries are labor-intensive and repetitive, and thus prone to automation. As manual jobs are gradually displaced, causing unemployment, the result will be a huge decline in living standards. The reliance on public services like housing and healthcare will be more intense. Unlike their developed counterparts, developing countries are financially prevented from offering a nationwide social security system and universal healthcare to their citizens. Adding to this challenge is that the aging population also demands resources from the government in terms of health care and support for the elderly. The aging of the population may become more severe as the younger generation leaves the country in pursuit of work.

The non-aging developing category is the most challenging one both socially and economically. Young people who aspire to a just and equitable society will be a formidable political force, exerting pressure on the ruling government. As many developing countries do not have political systems that facilitate the smooth transition of governments, radical protests may provoke political conflict and instability. These political demands may result in a change of regime, often accompanied by violence and catastrophic consequences that take decades to recover from. There may also be calls for protectionism, demanding that governments compel companies and international corporations to guarantee jobs for local workers. Relationships between governments and citizens may thus worsen, leading to social and economic instability. There may be an increase in crime, violence, and unrest, which will disrupt the social order and weaken social cohesion.

The situation facing each group of countries demands a different set of policies regarding talent acquisition and immigration. In aging developed countries, governments should consider lowering immigration requirements to attract young people from developing countries and facilitate the emigration of the elderly to neighboring countries, where living costs for retirees are lower. Due to the reluctance of employers to provide training for elderly workers, there is a shortage of talent to fill high-skilled jobs. With more resources than their developing counterparts, these countries can provide incentives including scholarships, work visas, and ultimately citizenship to attract young talent to replenish the retired workforce. Other supporting services should be provided, including assistance with housing, language learning, and education, to help immigrants settle down and get accustomed to a new work environment and lifestyle. This new workforce has the potential not only to meet the manpower needs of the country, but also to contribute tax revenue, and its spending will benefit the economy. Previous research has provided empirical evidence that the earnings of natives are positively linked to the number of immigrants.

For the elderly population seeking comfortable retirement, governments can cooperate with neighboring countries with lower living standards to provide retirement destinations. Although the spending power of retirees is relatively low, the countries that host them would also benefit from this arrangement. It could also ease the burden on the working family members of retirees. Many retired Hong Kong citizens live in retirement facilities in the southern part of mainland China, which provide more leisure space and better personal care services than those offered in Hong Kong.

In non-aging developed countries, governments should consider a merit-based immigration system. Employers in these countries are more willing to retrain young employees with new skills and responsibilities. These countries can be more selective in recruiting talents to attract those with skills most in demand. As there is no urgent need to increase the working population, these countries should be more methodical, attracting migrants who best suit their needs. As non-aging developed countries are likely to be self-sufficient in workforce development in the long run, the quality of immigrants is more vital than their quantity. Australia, a developed country, practices point-based immigration. Skilled immigrants have a 96% labor participation rate, higher than the national average of 67%. Skilled immigration can help boost demand and contribute to the economic development of the country, and speed the transition toward a digital economy.

Developed countries, aging or not, are more capable of attracting talent than their developing counterparts, and they are also better able to accept migrants for humane reasons. These countries should not close the door on those who cannot bring in immediate economic benefits. Rather, they should let migrants take up service-oriented jobs that are less technical and cannot be easily replaced by automation.

In non-aging developing countries, the job market for the low-skilled manufacturing sector will shrink due to automation. These countries are at a lower technological level and have lower education standards than developed countries, making the transition to a digital economy difficult. Large-scale unemployment may occur among the younger population, creating a very unstable political and economic situation. To address these challenges and achieve a win-win situation, these countries could work with developed countries with labor shortages by encouraging their young citizens to work in hosting countries on a short-term basis. For example, more than 10 million Filipino citizens currently work overseas, sending US$28.1 billion back to the Philippines every year (Karunungan, 2018). Hong Kong faces constant labor shortages, and the availability of live-in domestic helpers enables more females to participate in the workforce, who might otherwise need to stay home to run the household. These overseas workers can work in pre-approved professions and be protected by labor laws in the host countries. However long they stay, such an arrangement does not automatically lead to immigration. This arrangement helps ensure that host countries are receptive to foreign workers, and at the same time eases political pressure from local people, as they no longer perceive immigrated workers as a permanent threat to their jobs. In addition to the economic gain, the reduction of unemployment among the young helps prevent political instability in their mother countries. In Japan, the government recently passed a bill to relax restrictions on the importation of foreign labor for selected industries (e.g. retail, construction, healthcare) that are facing acute shortages of workers. To further facilitate the integration of foreign labor into society, the Japanese government has established Japanese language training centers in a number of Asian countries (e.g. Vietnam) to improve the language skills of the workforce before they arrive in Japan. This partnership between aging developed and non-aging developing countries is an example of cross-border collaboration that can meet the needs of both countries.

Of the four categories, aging developing countries face the greatest challenge, because they do not have the advantage of technological knowhow and a young labor force. In addition to efforts to improve education, these countries are still developing and need to gradually accumulate talent. The objective of the governments of these countries is to prevent a drastic decline in living standards, especially in the case of unemployment, which will inevitably lead to a decrease in income. Conventional policy instruments applicable to developed countries may not be applicable to these aging developing countries, or these countries may simply lack the prerequisites for policy implementation. However, because citizens of these countries also realize the dire situation facing their governments, they can be more open to radical approaches to chart a new course of economic development for their country. Such measures may include strategic cooperation with a developed country, an approach that might have in the past met strong political resistance due to a desire for sovereignty and national pride. Examples include leasing land for infrastructure development and installation of massive solar panels to generate energy for developed regions where land is scarce, then reselling the power back to the investing countries.

Investment in Healthcare and the Provision of Universal Healthcare

Automation will intensify the challenges facing countries with an aging population in Asia Pacific. It is estimated that the number of aged citizens will be more than double, from 535 million in 2015 to 1.3 billion in 2050 (ESCAP, 2017). As the human life span increases, it is important to promote a healthy lifestyle for the aging population and to improve elderly care. One way is to build hospitals and care centers to meet rising demand in decades to come. There is also a need to increase the number of care centers and mental health facilities for the aged population, offering services to cope with disabilities and age-related diseases such as dementia and Parkinson's disease.

As elderly care facilities increase in number, more healthcare professionals will be needed. As a caring attitude and empathy are core qualities of elderly care professionals, jobs in this sector are less likely to be taken up by machines in the near future. As the demand for care providers will continue to grow, attracting talent to the healthcare industry should be at the top of the policy agenda. As discussed earlier, governments could retrain workers displaced by automation in other industries to serve in the healthcare industry. Government spending on healthcare should focus on attracting people to the industry, in addition to investing in technology such as surgical robots to ease the workload for healthcare workers and professionals.

The cost of preventative healthcare is always much lower than that of medical treatment. Therefore, apart from building more facilities for training healthcare workers, governments should develop technological solutions for patient management systems to facilitate regular monitoring of its citizens' health conditions. To this end, big data and sensor technologies will be necessary to achieve an effective and automated medical monitoring process for the aging population. The Electronic Health and Recording Sharing System in Hong Kong is an example of a centralized patient record database that enables healthcare providers and professionals to retrieve timely and accurate information, facilitating efficient, quality care and reducing duplicate tests and treatment. It also enables better disease tracking and public health monitoring, making it easier for the government to formulate public health policies. The system also reduces administrative costs and human errors associated with paperwork. Increased efficiency in the healthcare system will lower healthcare costs, which facilitates the reallocation of financial resources to providing quality elderly care services in other areas. Aging countries should invest more in digital healthcare technologies. Success in this endeavor not only helps the country but also provides opportunities to export innovations to other countries.

Preparing the workforce for an automated work environment is not only about equipping them with new skills. As workers transition from a traditional to an automated work environment, they will experience psychological and social challenges that could negatively affect their mental state and well-being. A job is not only about making ends meet; it is the source of self-esteem that underlies social status, family relationships, and community participation. Losing a job not only affects a person's financial situation, but has an adverse impact on a person's mental state. According to a 2013 survey of Americans as part of the Gallup-Healthways Well-Being Index, 18% of American adults have been treated for depression after remaining unemployed for 27 weeks or longer, and the unemployed are more than two times more likely than the full-time employed to indicate that they have been treated for depression (Crabtree, 2014). The same survey also found that those who had been unemployed for a long period of time were less likely to spend time with family and friends. In other words, job status affects our mental health and the effects extend to different areas of our lives.

Based on General Social Survey data and county-level data from the US, Patel, Devaraj, Hicks, and Wornell concluded that automation induces job insecurity in workers, which leads to poorer health (Patel et al., 2018). In their study, counties that were predicted to be most affected by automation were lower in their broader health ranking, which included factors such as lifespan, access to care, and alcohol and drug use. Many developing countries in Asia Pacific countries score low in these dimensions. If the workforce is not mentally well-prepared for automation, the transition could further strain the already overburdened healthcare budget in these countries.

Governments should take an active role in mitigating the potential public health risk resulting from automation, including launching public mental health awareness campaigns and developing programs to support workers in automated environments through community health or social welfare offices. Creating a stronger network of public services to help affected workers and establish training programs to help people understand and prepare for transition are important for reducing fears of an automated future.

Finally, governments should consider establishing a universal healthcare system to provide basic healthcare services to every citizen. This system would serve as a safety net, especially for low income citizens who are most vulnerable to automation. In many countries, full-time workers rely on corporate medical insurance coverage. The medical protection ends when they quit or lose their job. Governments, therefore, should provide a healthcare safety net for displaced workers who are between jobs or retraining. This will allow them to stop worrying about healthcare protection and focus on comprehensive training to equip them with the skills necessary for a new career.

A universal healthcare system also reduces the linkage between jobs and health insurance, making healthcare benefits more available to every citizen. When a society moves toward a highly digitized environment that may result in changes in the labor market, a universal healthcare plan becomes a safety net for people with income loss. In countries that do not currently have a universal healthcare system and may not be able to afford one, governments should consider subsidizing medical insurance for displaced workers for an extended period providing that the worker participates in a retraining program for a new career in high demand (e.g. caring professionals).

Income Inequality and Transfers

The globalization of the world economy since the 1970s has increased income disparity and inequality in many developed countries. The benefits of outsourcing and offshoring are not distributed evenly, with the top earners reaping the most. According to the OECD, the average income of the richest 10% is about nine times that of the poorest 10%. This trend is also observed in developing countries. China's GINI Index stood at around 30 in the 1980s and grew to 42.2 in 2012 (World Bank, 2018). One of the findings of the World Economic Forum Global Risks Report is that there are strong connections between income disparity, unemployment, and social unrest (WEF, 2018).

As indicated earlier, due to the extreme scalability and close-to-zero marginal cost of IT automation products, the probable economic consequence of automation is a very high concentration of industries. This concentration translates into a disproportionate return for the few providing automation, whereas the wages of the average worker will decline. If market forces are allowed to take their course, social and economic inequality will continue to grow. It is critical that the disruption of the workforce due to digital automation be managed well. During the transitional period, some workers will be temporarily unemployed as they adjust to the skill shift in the labor market. Workers need time for retraining and to look for new jobs, so they should be given protection during this period. Unemployment insurance that covers a reasonable period would be helpful for those who will re-enter the labor force.

After the initial transitional period, workers who do not return to the labor force are likely to be permanently unemployable. The mandatory saving schemes that are currently in place in some Asia Pacific countries aim to support the workforce when they reach retirement age. However, those permanently unemployed or unemployable must rely on social welfare support that may only last for a short period of time. Governments need to explore novel approaches to support a potentially large proportion of the working population over a transitional period without creating social unrest and political instability.

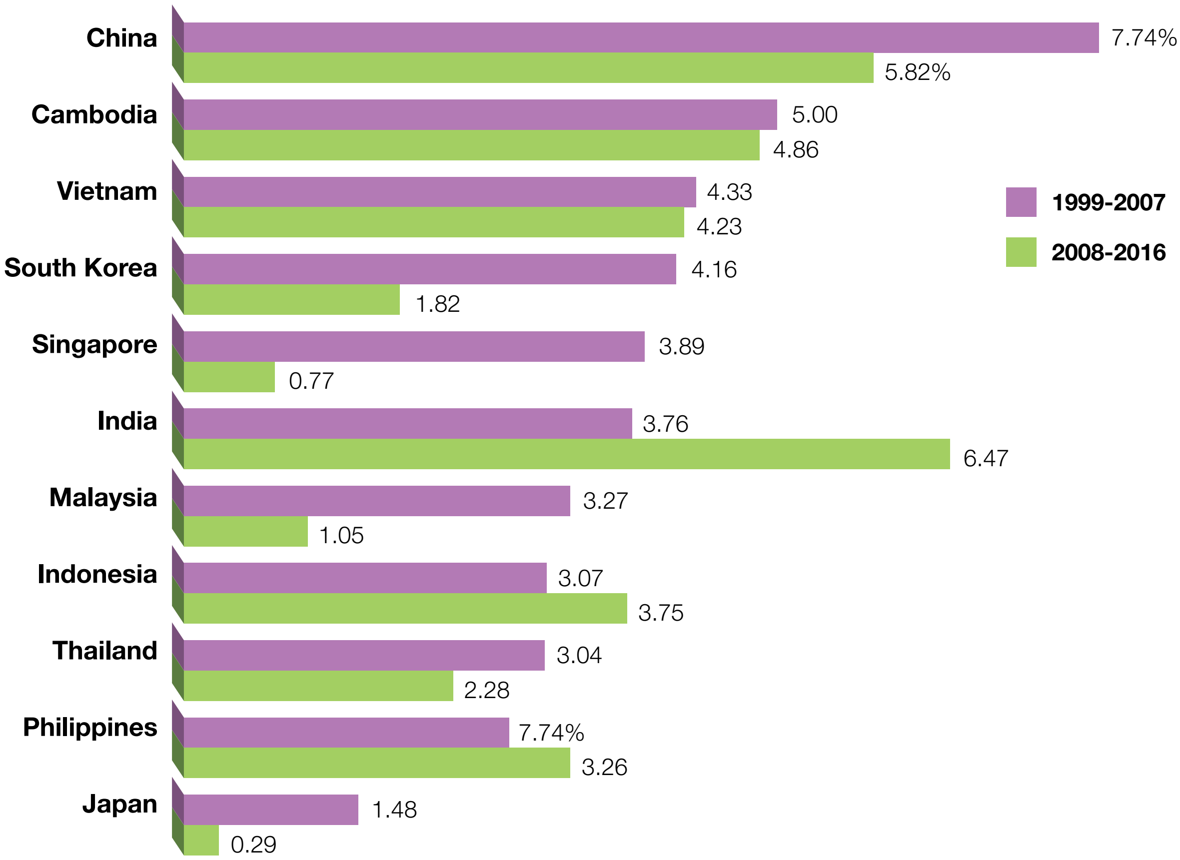
Universal Basic Income (UBI) is often favored by those who see its potential to reduce injustice and poverty (Bregman, 2017). To prevent unemployment that will in turn generate even greater income disparity, a basic income guarantee is a plausible means to protect those whose jobs are vulnerable to automation. According to the Basic Income Earth Network, a universal basic income program costs less administratively and require less paperwork and bureaucracy, as it is distributed to all citizens equally without the administration of a means test. However, governments will need to find viable income sources to finance UBI. There are many UBI trials in different parts of the world, and evidence for its effectiveness so far is mixed. In 2016, Swiss voters rejected a proposal to introduce a guaranteed basic income for all. In 2018, the Finnish government decided to end Europe's first national government-backed experiment in UBI. These Nordic countries have more financial resources than most Asia Pacific countries, and their hesitation over UBI should be a point of reference for these countries in formulating their own policies. UBI will remain a topic of policy debate in the coming years.

Whether UBI is adopted or not, government expenditure on social welfare and retraining is bound to increase. An unemployed workforce can no longer contribute tax revenue. To make up for loss of taxes, one suggestion for policy makers is taxing companies that automate heavily. The idea is similar to the Robot Tax suggested by Bill Gates (Delaney, 2017). The underlying principle is to tax companies that exceed a certain number of layoffs within a given period. It is hypothesized that imposing such taxes will slow down the unemployment impact, while creating an extra tax revenue source for the government. However, the downside would be that companies not welcoming the robot tax and layoff tax would move their operations offshore. Those against an “automation tax” argue that such a policy would stifle innovation.

Prioritizing Competitiveness, Innovation, and Trade Position

A poor understanding of automation among management in Asia Pacific hinders industrial automation. Technology introduced in the manufacturing and logistics industries 20 years ago as a result of massive outsourcing to developing countries in Asia Pacific is now outdated, resulting in slow productivity growth in recent years. As shown in Figure 7, with the exception of India, Indonesia, and the Philippines, many Asian countries experienced a drop in labor productivity over the last decade.

Figure 7: Growth of labor productivity per person employed in Asia



Source: The Conference Board Total Economy DatabaseTM, May 2016 is based on projections by The Conference Board. China's productivity growth rate is calculated by The Conference Board's alternative growth measures for China, please refer to the Conference Board, Frequently Asked Questions on THe Conference Board's Alternative China GDP series, November 2015.

Automation will affect every sector of the future job market. It is important for governments to identify and analyze the potential for automation for each sector and its potential impacts on labor supply and demand. Retraining programs funded by governments should be implemented in sectors that contribute most to national economic growth, to increase competitiveness, innovation, and trade position on a global scale.

The potential for automation varies from country to country, and technical feasibility is one of the factors that determine the adoption of automation. Labor supply and demand and regulatory and social acceptance are other factors affecting the pace and extent of technology and automation adoption. For example, China and India may experience the largest potential unemployment impact because of the size of their labor forces. Therefore, their governments should aim to achieve automation progressively, across a longer period of time. As more young citizens enter the workforce with better STEM training, these countries' capacity to adopt new technology will increase over time.

Developing an Ecosystem that Helps Large and Small Firms Co-exist

Unlike large corporations, SMEs lack the financial capability to adopt new equipment and tools to pursue automation. However, large firms may have already made significant investments in older technologies and lack the incentive to replace them before they are fully depreciated. Due to the scale of replacement, it is difficult for large corporations to scrap what they have and purchase new equipment and tools, develop new organizational structures, and retrain staff. Smaller firms are more flexible and agile, which means that they can experiment with new technologies in a cost-effective manner. This contrast is especially true for innovations that are software-based and delivered over the Internet. The availability of cloud services makes experimentation and pilot runs very feasible and scalable. Furthermore, as a wide range of industries adopt open application interfaces (open APIs), firms will allow trusted third parties to access data that was once proprietary.

The government can take the lead in open API development by opening up access to government data via APIs. In a number of Asian countries, environmental, economic, traffic and other government data are now publicly available. In Hong Kong and Singapore, where the financial industry is a pillar of the economy, regulators are establishing guidelines for banks to open up their data to trusted parties so as to increase the quality and range of services offered. To help the financial industry to embrace automation via competition, the Hong Kong Monetary Authority issues new virtual banking licenses that have attracted applications from non-financial firms. This approach serves as an example of how a government can play an active role in creating an ecosystem in which established industry incumbents can collaborate with new entrants to facilitate the adoption of technology and collectively move the industry toward the next phase of development.

Many new entrants are small agile technology-based SMEs. If big and small firms work together, they can complement each other in embracing digital automation. Providing financial support such as funding and tax incentives for SMEs could help remove financial barriers for purchasing new technological tools. Small firms also serve as a good source of innovation and job creation. Two extensive studies conducted by Deloitte on Indonesian and Indian SMEs found that by embracing digital technology, there would be 1.5 times the present likelihood of increasing employment and 17 times the current potential for innovation for Indonesia, and an 84% likelihood of increased employment and up to 65% likelihood of greater access to international markets for India (Deloitte University Press, 2017). Governments could set up programs at the national level to support SMEs' adoption of technology, including training, matching support for R&D, tax incentives for R&D expenditure and training on approved topics, facilitating SME loans by banks, and encouraging collaboration between technology vendors and SMEs.

Upgrading Communications and Transportation Infrastructure

In the future, jobs will become more fragmented and transaction-based. Instead of working full-time for a single company for an extended period of time, individuals may have many jobs and roles in different industries over their lifespans, with intervals between jobs for retraining and the pursuit of personal goals such as family, hobbies, and volunteer work. As an increasing proportion of the working population adopts a lifestyle integrating work and life, more workers will work remotely from home. Meetings and presentations will be conducted online with high fidelity audio and video interfaces. This new work environment will require a reliable and efficient communications infrastructure.

In addition, an efficient infrastructure to facilitate the flow of people and physical goods will help nations compete globally. Good infrastructure providing access to reliable, efficient, and affordable services can increase productivity and promote economic growth by facilitating the connection between people, ideas, and technologies. Communications and transportation infrastructure is especially important for connecting different parts of a society, enabling increased productivity, shortening travel times and costs, and creating jobs. Building a systematic and comprehensive network for logistics and trading not only enhances connections within the country, but also enables trade with other countries. The World Bank Group's 2017 report on infrastructure services in East Asia and the Pacific region is a good reference for areas on which governments should focus to improve infrastructure services in their countries (Figure 8).

Figure 8: The status of infrastructure services in East Asia and the Pacific

Summary of Status Indicators: Good | Fair | Poor | Neutral | No information

	ACCESS								TARIFFS& COST RECOVERY					QUALITY								
	Electricity			Water		Sanitation		Roads	Electricity			Water		Electricity			Water		Sanitation		Roads	
	Overall	Urban	Rural	Piped Water	Urban Piped Water	Improved Sanrtation	Urban Piped Sewerage	Rural Road Access	Res. Tariff	Avg. Tariff	Avg. Tariff- Avg. Cost	Res. Tariff	OCCR	Quality Electricity	T&D Losses	Interruption Frequency	NRW	% Pass Chlorine Test	DALY Index	%WW Treated	Road Quality	% Paved
China	100	100	100	73	87	76.5	85.6	-	0.07	0.10	0.05	0.29	0.76	5.3	5	0.23	20.5	99.9	5	28.8	4.8	-
Cambodia	56.1	82.8	49.2	21	75	42.4	44.8	86.7	0.15	0.19	-	0.16	2.57	3.3	23	19.88	6.7	100	3	0.0	3.4	11
Indonesia	97.0	99.4	94.3	22	33	60.8	-	57.2	0.05	0.07	-0.03	0.46	1.39	4.2	9	1.72	30.4	65.7	3	1.0	3.9	57
Laos	78.1	94.7	68.1	28	64	70.9	1.3	35.3	0.06	0.07	-	0.25	1.07	4.7	-	9.42	20.9	100	1	0.0	3.4	15
Malaysia	100	100	100	96	100	96.0	42.2	48.9	0.07	0.10	0.02	0.14	1.15	5.8	6	0.48	34.4	97.6	5	61.6	5.5	78
Myanmar	52.0	57.9	49.0	8	19	79.6	9.5	58.9	0.04	0.06	-	0.08	-	-	20	-	-	-	2	0.0	-	55
Philipines	89.1	97.3	82.5	43	59	73.9	4.7	84.5	0.20	0.21	-0.11	0.45	2.40	4.0	9	2.71	42.6	93.9	3	40	3.1	81
Thailand	100	100	100	57	76	93.0	8.7	86.7	0.21	0.11	0.02	0.24	-	5.1	6	1.37	-	-	4	44.7	4.2	81
Vietnam	99.2	99.8	98.9	27	61	78.0	3.9	52.9	0.07	0.08	-0.01	0.25	1.51	4.4	9	6.72	22.9	92.4	4	55	3.5	66
Fiji	100	100	76.3	68	96	91.1	-	-	0.08	-	-	0.07	0.59	-	-	8.00	45.4	92.1	4	10	-	-
Papua New Guinea	20.3	76.4	11.9	9	55	18.9	-	21.4	0.25	-	-	0.42	1.78	-	-	134.00	38.4	99.9	1	0.0	-	-
Samoa	97.9	99.2	97.6	85	91	91.5	0.5	-	0.67	-	-	0.50	1.26	-	-	20.00	62.1	94.1	3	-	-	-
Solomon Isl.	35.1	39.4	33.9	26	61	29.8	-	-	0.78	0.90	-	0.73	1.47	-	-	3.20	57.8	89.7	2	-	-	-
Timor-Leste	45.4	63.0	37.0	25	47	40.6	18.2	46.8	0.12	-	-	0.00	-	-	-	-	-	-	1	-	-	-
Vanuatu	34.5	100	11.5	35	61	57.9	6.6	-	-	-	-	-	-	-	-	7.49	18.2	100	2	-	-	-
Brunei	100	100	100	-	-	-	-	92.2	0.01	-	-	0.08	-	5.3	6	0.40	-	-	5	-	4.7	93
Singapore	100	100	100	100	100	100	100	100	0.21	-	-	1.20	-	6.8	2	0.01	3.8	100	5	100	6.3	100
Japan	100	100	100	98	99	100	-	-	0.18	0.24	0.13	1.07	-	6.5	4	0.12	-	-	5	75.8	6.1	-
New Zealand	100	100	100	100	100	100	-	-	0.20	-	-	1.00	1.98	6.3	7	1.84	19.5	-	5	82	4.5	-
South Korea	100	100	100	-	99	100	90.1	94.82	0.05	0.10	-	0.52	2.48	6.20	3	0.08	16.3	-	5	91.5	5.6	-

Source: World Bank Group (2017). The Status of Infrastructure Services in East Asia and Pacific.

Developing countries have the opportunity to leapfrog over older-generation technologies in which developed countries have already invested heavily. For example, developing countries can provide a communications network covering the entire region using mobile networks without installing expensive landlines. Solar panels have become affordable, allowing residents in remote areas to access electricity before a country-wide electricity distribution network is built. By unleashing the potential of technology, developing countries can identify unique opportunities that allow progress to be made swiftly and economically. Governments should be restrained from investing in mega-infrastructure projects for reasons of national pride and populism. Planning must be done carefully, with a high degree of scrutiny by public and international organizations, to avoid excessive debts from funding infrastructure projects.

Issues with Automation: Biases and Lack of Explainability

Automation is affecting many facets of society, and automated systems are shaping our daily life in unprecedented ways. Understanding whether and how ethics should be incorporated in these decisions is imperative. Automated decisions by machines raise a number of ethical issues that have attracted media attention. Two issues are addressed here: bias and the poor explainability of decision outcomes.

Automated systems are built on AI, and machine learning algorithms are sensitive to the sources and quality of data used to develop them. If not properly validated, the decisions of these systems may reinforce intrinsic biases and past norms that are no longer relevant or socially acceptable. Boulamwini and Gerbu (2018) reported that commercially available facial recognition systems perform poorly for the faces of women and people of color. Recently, Google stopped the use of an AI recruiting tool, as it showed gender bias (2018). These decisions can be traced back to biased data samples that led to unbalanced outcomes. For example, criminal risk assessments based on historical inmate records could be biased against certain genders, races, and ethnicities. The unimpeded deployment of automated systems could perpetuate social injustice and inequality. Society needs to be alert to the potential of entrenched social biases in automated systems. If used maliciously, these systems could cause physical and psychological harm to individuals and reduce the security and justice of society as a whole. Although a comprehensive policy to mitigate the risk of biased data may not be practical, governments and nongovernmental organizations should take the lead in developing good practices, starting with government services. This goal can be achieved by revealing the inner mechanisms of algorithms and data sources and validating the outcomes for selected public services. For regulated industries (e.g. utility, transportation), the government can instruct regulated parties to disclose the decision mechanism of their systems. In general, the design and deployment of automated systems should involve experts in data science, end users, and domain experts to ensure that data sources are of high quality with known characteristics. Validation should be performed not only on the overall accuracy of the system but over different decision outcomes.

Another challenge of existing automated systems is their lack of explanatory capacity. This shortcoming limits their application to domains where predictive accuracy is the primary criterion, not explanation. However, for systems that involve human subjects (e.g. medical diagnosis, vetting of loan applications, risk assessment of individuals), decisions need to be explained in human terms to be legally and socially accepted. The current black box approach in building automated systems has its roots in decision models that involve hundreds or thousands of parameters and their nonlinear interactions, which are extremely difficult to articulate. For engineering problems, these nonlinear mappings carve out the decision boundaries of objects (e.g. facial recognition). As long as the predictive accuracy is acceptable, the ability to explain an outcome is of lesser priority.

However, accuracy is not the only criterion for decisions in social and economic settings. Very often, the chain of inferences that leads to a decision is as important as the end decision itself. The over-emphasis on empirical inference in comparison with symbolic inference in recent AI development has widened the research gap concerning the explainability of automated systems. In addition to encouraging more research on the explainability of AI systems, governments and academics should work together to identify public services that benefit from a heightened level of explainability. A starting point could be regulated industries in which the government is already demanding justifications for decisions made by regulated parties. For example, banks all over the world have been investing heavily to strengthen their anti-money-laundering compliance procedures. Suspicious transactions are reported to regulators or law enforcement agencies. In this case, spotting a suspicious transaction with high accuracy is not enough. An explanation is needed. Another case is financial service applications (e.g. loans) where applicants in many jurisdictions have the right to know why their applications were rejected. Simply reporting the outcome of a deep learning algorithm without explanation is not acceptable. In recent years, the retail banking and brokerage industries have been deploying more robo-advisors to offer investment advice to individuals. There will be disputes and legal claims if machine-generated advice is not accompanied by explanations that human investors can follow and relate to. Under the Equal Credit Opportunity Act in the US, creditors are required to inform applicants of actions taken in certain circumstances, and such notifications must provide specific reasons. Under the European Union General Data Protection Regulation, citizens have a right to an explanation of a decision.

In fact, the ability to explain is the nexus connecting two key concepts: the attribution of responsibility and the moral dimension of a decision. Without an explanation, it is impossible to conduct further analysis of a decision or judgment. Rejecting a loan application because the applicant has defaulted twice is very different from rejecting an application because the applicant is female and does not reside in an affluent neighborhood. The latter case reveals the likelihood of a biased algorithm and the need to review its data sources and underlying mechanism. In the case of predictive maintenance, an explanation of a decision to replace a component helps to identify the source(s) of failure and the supplier(s) responsible for the failing component. An explanation not only provides a basis for a decision, but can also provide useful feedback to enhance the decision quality of the algorithm. The need to provide explanations has spurred research in recent years. In neural network learning algorithms, layerwise relevance propagation is a technique proposed to determine which features in a particular input vector contribute most strongly to a neural network's output. The DARPA XAI program aims to produce models that are explainable to humans and can extract knowledge from black-box learning models (Bach et al., 2015). The role of the government is to highlight the importance of explanation in decisions/judgments involving human subjects, and it can begin by mandating explainable decisions in selected online public services. Doing so can drive research and investment to address this important issue.

Increasing dependence on automated systems involves a range of ethical, legal and regulatory issues that society must address. A framework is needed to address the ethical, legal, professional, and behavioral aspects of the development and use of robotics and autonomous systems. An office should be established to provide guidelines and proactively develop, review, and implement policies to facilitate the transition to automation. The office should work closely with technology providers to understand the nature and potential of emerging technologies, and also work with business leaders to shape a supportive regulatory environment that best fits society. The office should also interface with the public to ensure that its regulations reflect societal norms and preferences, and to keep the public informed about these regulations.

Conclusion

As digital automation continues to transform every aspect of society, we must keep an open mind toward changes, recognize the potential of new technologies, and come up with ways to foster organizational innovation and new skills to harvest the benefits of automation.

The future of work is uncertain. It is not possible to predict exactly the trajectory of digital automation and how it will transform Asia Pacific economies. However, adequate knowledge of the subject will certainly facilitate an informed discussion to help society as a whole prepare for the changes. Therefore, this chapter looks into the impact of digital automation across different industries and countries, including some early measures put forward by several nations. Before any best efforts made in retraining or reinvestment, it is important for policy makers and educators, business and community leaders, to better understand the nature and magnitude of disruptions and opportunities ahead.

Our recommendations are the tip of the iceberg in terms of supporting the broader digital transformation already taking place. These recommendations are intended to encourage policy makers and business leaders in the region to make digital automation a top priority. Although governments can provide resources, policies, and regulations to facilitate the transition to automation and mitigate the risks involved, as the authors in the book have argued, most jobs of the future do not yet exist. The ultimate goal is not to train people for jobs that are still unknown to us, but to ensure that we are versatile and agile enough to meet the new challenges ahead. We need to learn new skills, not only to mitigate the unemployment and inequality that may result from new technologies, but also to enjoy new ways of living that will bring forward by digital transformation.

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