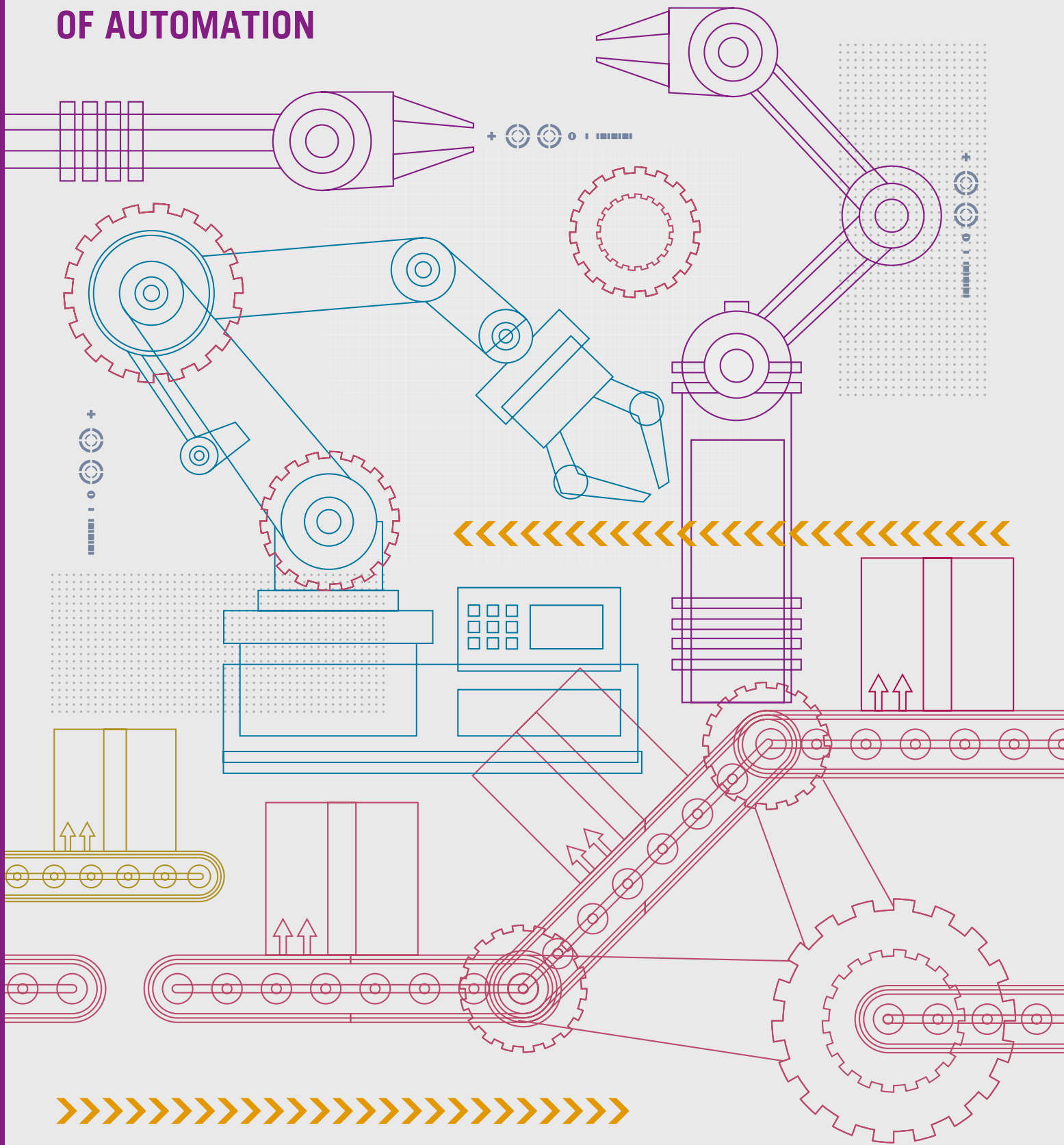
ASEAN IN TRANSFORMATION

THE FUTURE OF JOBS AT RISK OF AUTOMATION



International Labour Organization

ASEAN IN TRANSFORMATION

THE FUTURE OF JOBS AT RISK OF AUTOMATION

July 2016

Jae-Hee Chang and Phu Huynh

Bureau for Employers' Activities, Working Paper No 9

International Labour Office

ILO Cataloguing in Publication Data

Chang, Jae-Hee; Huynh, Phu

ASEAN in transformation : the future of jobs at risk of automation / Jae-Hee Chang and Phu Huynh ; International Labour Office, Bureau for Employers' Activities ; ILO Regional Office for Asia and the Pacific. - Geneva: ILO, 2016 (Bureau for Employers' Activities (ACT/EMP) working paper ; No. 9)

ISBN: 9789221309659 (web pdf)

International Labour Office Bureau for Employers' Activities; ILO Regional Office for Asia and the Pacific

future of work / technological change / automation / promotion of employment / social implication / ASEAN countries

13.01.1

Layout and design by QUO, Bangkok

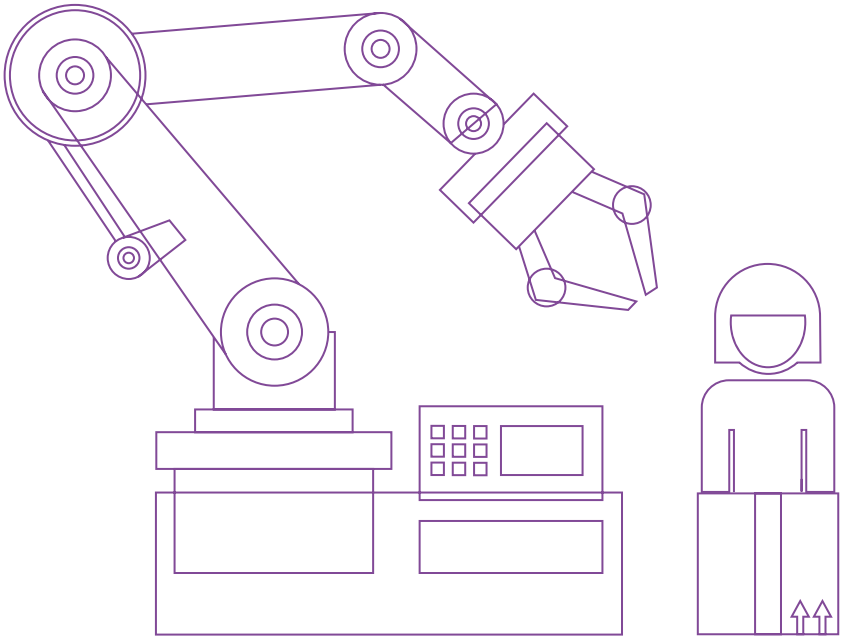
PREFACE

The world is experiencing an unprecedented acceleration in technological advancement and implementation. Indeed, profound shifts are taking place – entire sectors are accommodating these innovations, rendering several human-performed occupations redundant. In the near future, these positions may be eliminated entirely. At the same time, other jobs are experiencing a rapid increase in demand, and some occupations are revising the skill sets they traditionally require.

Discussions surrounding this topic are often polarized, with one side expressing excitement for the opportunity to improve product quality and living standards, and opponents voicing grave concern regarding the massive dislocation of jobs. However, a proper grasp of this topic requires a sector-specific understanding, as not all sectors are impacted equally by these advances in technology.

The ILO Bureau for Employers' Activities (ACT/EMP), together with the ILO Regional Office in Asia and the Pacific (RO - Asia and the Pacific), extensively researched this subject in 2015 and 2016. Drawing from numerous interviews and case studies, the team examined current technological trends in the ASEAN region and how they impact enterprises and workers within five major sectors: automotive and auto parts; electrical and electronic parts; business process outsourcing; textile, clothing and footwear; and retail. Alongside these in-depth sectoral studies, the ILO gathered 4,076 survey responses from ASEAN enterprises in the manufacturing and service industries. Additionally, survey responses from 2,747 university and technical vocational education and training students were also collected, providing insights on the career aspirations and expectations of the next generation of workers.

Furthermore, 50 interviews with key stakeholders in six ASEAN countries, as well as early validation exercises with executives in Cambodia, Indonesia and Singapore, extended our qualitative insights. In November 2015, 23 global, regional and country experts examined



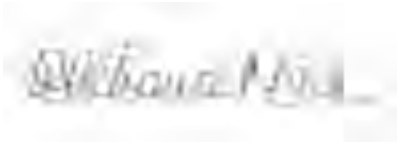
preliminary findings and identified additional research needs. In March 2016, mid-point research findings were shared and consultations were conducted with representatives of the ASEAN Confederation of Employers and the ASEAN Trade Union Confederation during a bipartite regional meeting on labour mobility. Ultimately, these efforts have culminated into a collection of papers, each providing an in-depth examination on different aspects of how technology affects the ASEAN region:

1. ***ASEAN in transformation: The future of jobs at risk of automation***
2. ***ASEAN in transformation: Perspectives of enterprises and students on future work***
3. ***ASEAN in transformation: Automotive and auto parts – Shifting gears***
4. ***ASEAN in transformation: Electrical and electronics – On and off the grid***
5. ***ASEAN in transformation: Textiles, clothing and footwear – Refashioning the future***

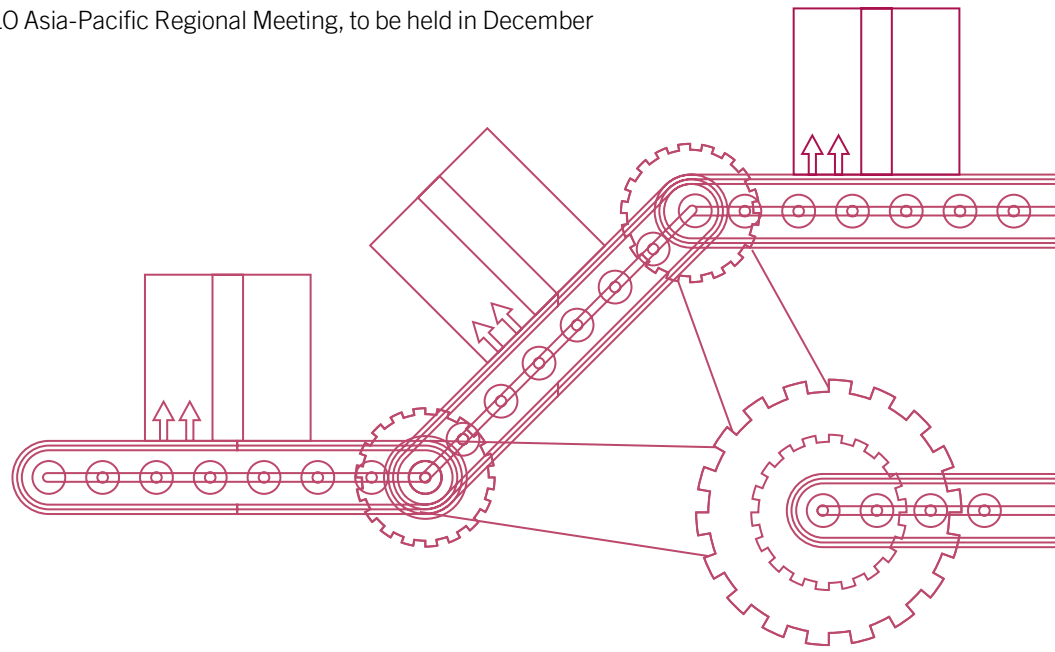
The findings for the documents above are synthesized in a master document titled, *ASEAN in transformation: How technology is changing jobs and enterprises.*

This working paper, *The future of jobs at risk of automation in ASEAN*, comprises one document in this collection. It is desk study that applies a research methodology developed by Carl Frey and Michael Osborne of the University of Oxford. This method assesses how susceptible occupations are to automation in the ASEAN region. The key findings of this technical paper are integrated into the master document mentioned above.

We hope this paper and its associated research provide enterprises, their representative organizations, governments, workers and other stakeholders with useful empirical evidence and a rich knowledge base from which they can initiate national level policy dialogues and actions to address the future of work. Finally, it is our hope that this research makes a constructive contribution to the ILO's on-going work related to the Centenary Initiative on the Future of Work, as well as the 16th ILO Asia-Pacific Regional Meeting, to be held in December 2016.



Deborah France-Massin
Director
Bureau for Employers' Activities
International Labour Office



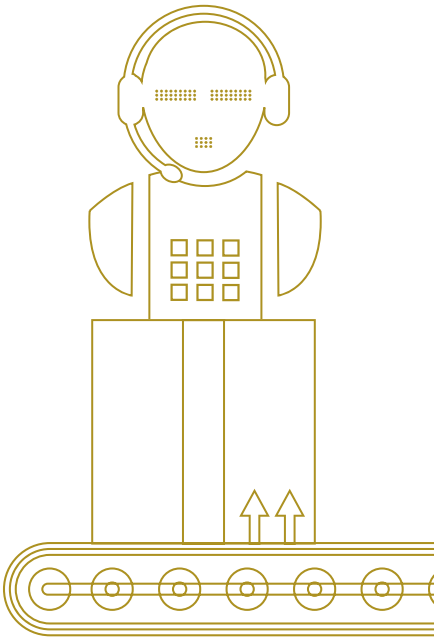
CONTENTS

LIST OF FIGURES AND TABLES

ACKNOWLEDGEMENTS

The authors acknowledge and are grateful to a number of colleagues and experts who supported this study and helped to shape their overall understanding of the topic.

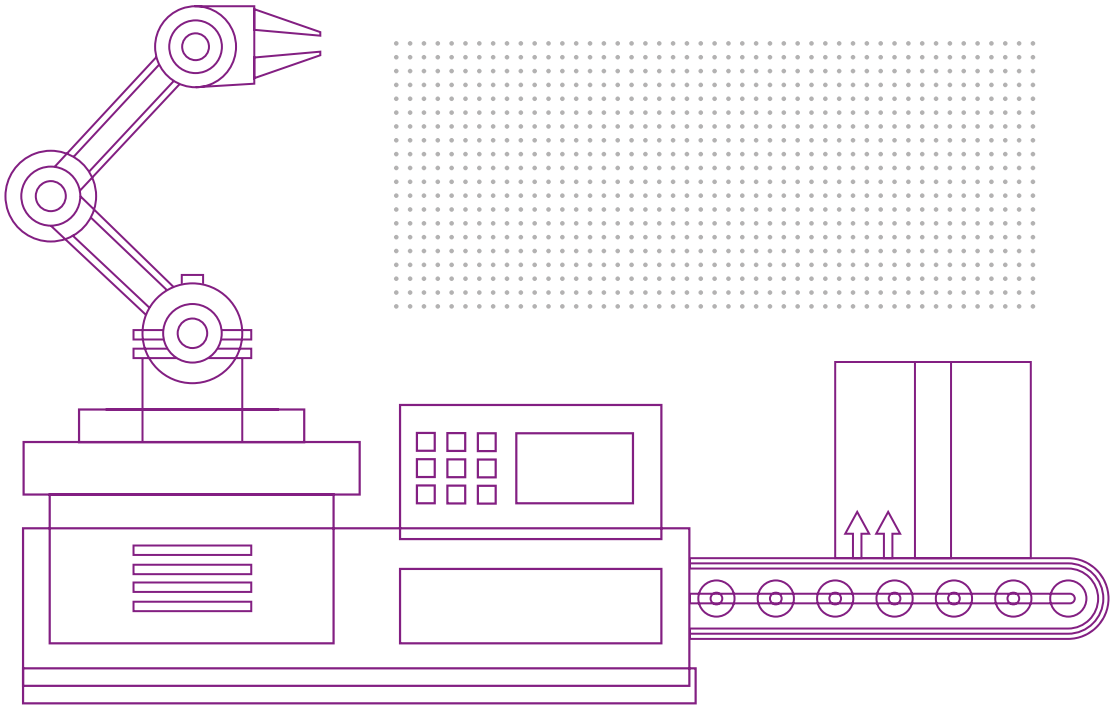
The paper benefitted significantly from a peer review process that included Roy Chacko, Senior Advisor, ILO Bureau for Employers' Activities (ACT/EMP); Henrik Moller, Senior Advisor, ILO-ACT/EMP; and Fernanda Barcía de Mattos and Richard Horne, ILO-RO Asia and the Pacific. Marko Stermsek assisted in the initial conceptualization of this technical paper. Overall technical guidance was provided by Gary Rynhart, Senior Employers' Specialist, ILO-Decent Work Technical Support Team for East and South-East Asia and the Pacific.



ABOUT THE AUTHORS

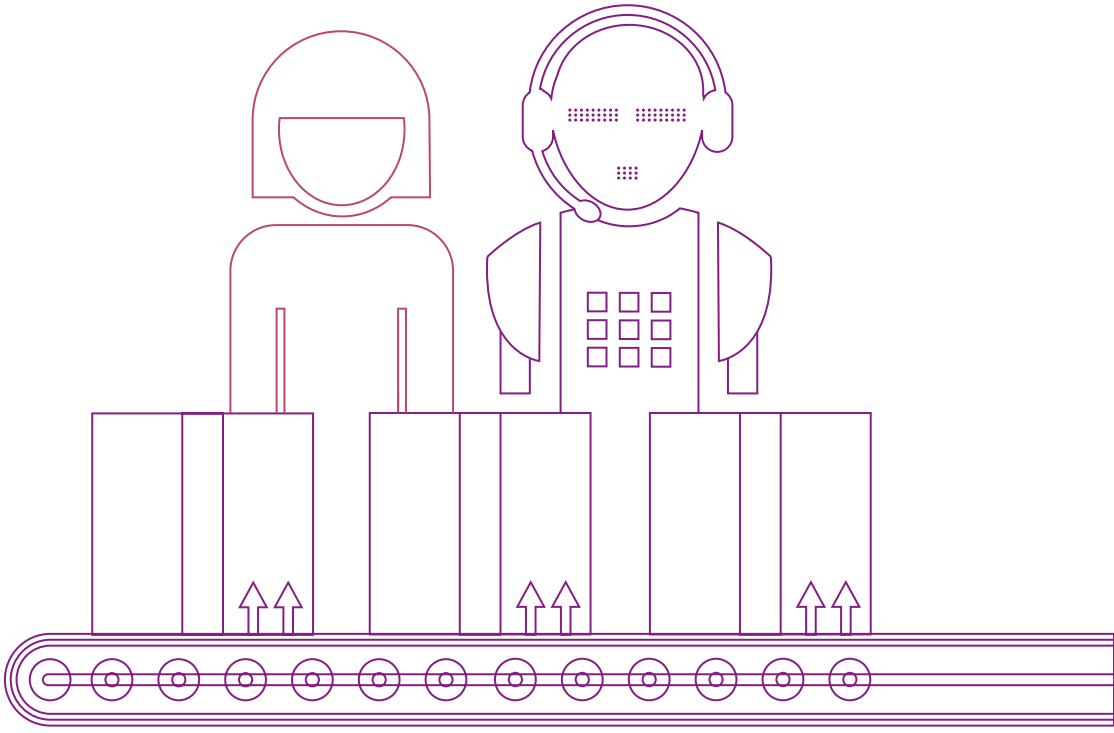
Jae-Hee Chang is the Employers' Specialist for ILO-ACT/EMP and primarily works to provide technical support to employers' organizations in service and policy development.

Phu Huynh is a Labour Economist based in Bangkok for ILO-RO Asia and the Pacific and is responsible for monitoring labour market trends and emerging policy issues throughout the Asia-Pacific region.



ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
BLS	United States Bureau of Labor Statistics
BPO	business processing outsourcing
ILO	International Labour Organization
ILO-ACT/EMP	ILO Bureau for Employers' Activities
ILO-RO Asia and the Pacific	ILO Regional Office for Asia and the Pacific
ICSE	International Classification by Status in Employment
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification of All Economic Activities
SOC	United States Standard Occupational Classification



INTRODUCTION

Technology and the workplace

In 2015, *The Economist* revealed that "a robotic sewing machine could throw garment workers in low-cost countries out of a job", citing advancements made by textile-equipment manufacturers in the United States.[1] These manufacturers have succeeded in developing robots and materials-handling systems that can stitch pieces of fabric together, pick them up and move them to another machine. That same year, Foxconn, a firm headquartered in Taiwan (China) that manufactures iPhones and employs more than a million workers in China, announced its plan to have robots complete 70 per cent of its assembly-line work by 2018.[2]

> "Foxconn, which calls its industrial robots Foxbots, has been striving to accelerate manufacturing automation amid rising labour costs and workplace disputes, and to free humans of the dirtiest and most dangerous jobs. While the company has automated more manufacturing processes for components and established some lights-out, or workerless, factories, replacing dexterous human hands that pack tiny flexible parts into the tight structure of consumer electronics remains challenging."
>
> Source: L. Luk: "Foxconn's robot army yet to prove match for humans", The Wall Street Journal, 5 May 2015.

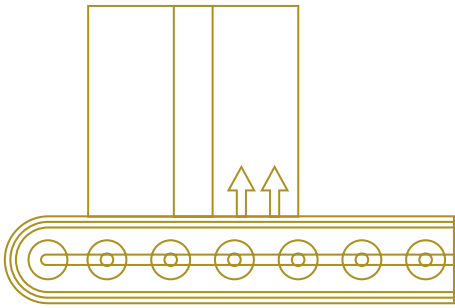
The quest for enhanced productivity, increased quality of goods, cost optimization and better working conditions drives the development and implementation of new workplace technology. The Industrial Revolution in the nineteenth century introduced the assembly line to manufacturers, creating mass employment for low-skilled workers and simplifying their tasks. In the twentieth century, the computer revolution hollowed middle-skilled manufacturing and clerical occupations, replacing repetitive production tasks with machines. Now, the twenty-first century's digital revolution has unleashed a new wave of advanced machines, further automating complex tasks and jeopardizing skilled workers in positions once considered difficult to automate.

Research increasingly shows that these disruptive technologies – predictive analytics, artificial intelligence, additive printing, the Internet of Things, nanotechnology, automation and robotics – are not only becoming better, but are also being combined. Decreases in their costs and increases in their accessibility promise future prosperity and the creation of new jobs. Simultaneously, these technologies challenge existing configurations of the workplace, forcing dramatic changes at alarming speeds. Unless enterprises, governments, policy-makers, workers and jobseekers proactively respond and adapt to these fast-encroaching technologies, opportunities may be lost and numerous industries may find themselves unprepared for the consequences. This is particularly true for developing and emerging economies.

1 The Economist: "Made to measure", Technology Quarterly, 30 May 2015, www.economist.com/news/technology-quarterly/21651925-robotic-sewing-machine-could-throw-garment-workers-low-cost-countries-out [accessed 2 Mar. 2016].

2 M. Kan: "Foxconn expects robots to take over more factory work", in PCWorld, 27 Feb. 2015, http://www.pcworld.com/article/2890032/foxconn-expects-robots-to-take-over-more-factory-work.html [accessed 2 Mar. 2016].

Understanding the implications of disruptive technologies for developing and emerging economies has thus far proven challenging, as the current archive lacks consistent data and, currently, there is simply a sheer absence of research conducted. It is therefore critical to study these economies in a rigorous manner, as they are more sensitive to the effects technology breakthroughs and susceptible to changes on wider and more profound scales than technologically advanced countries. Because developing and emerging economies often engage in singular, or less diverse, economic activities and also have a larger workforce in low-skilled employment with low educational attainment levels, preventative and proactive steps must be taken to avoid entire demographics from losing their jobs. These economies need to strategically transform in order to keep up with technology's advancement and implementation. Perhaps, these emerging and developing economies could even "leap frog" over others and gain a new competitive edge.



Technology and ASEAN

The Association of Southeast Asian Nations (ASEAN) is a particularly salient region for investigating technology and its effects on the workplace.[3] As a region, the Member States have a combined economy of US$2.6 trillion (forming the seventh largest economy in the world) and a population exceeding 632 million.[4] Investments in the region are increasing due to an increasingly better educated workforce, emerging consumer markets, expanding infrastructure and growing logistics networks. Furthermore, ASEAN has deepened its trade integration in the global market and made shifts from agriculture to manufacturing and services. These transitions have resulted in higher living standards, remarkable poverty reduction and a growing middle class workforce that is powering domestic demand.

In terms of technology, ASEAN is a very tech-savvy region. Mobile phone penetration is approximately 110 per cent with approximately 350 million mobile subscriptions added from 2008 to 2013, placing the region behind India and China.[5] Internet users also grew at 16 per cent annually for those five consecutive years.[6]

Yet, when it comes to implementing new technologies in the workplace, ASEAN enterprises tend to not stand at the forefront. They are perceived as followers of technology adoption rather than innovators.[7] In developed economies, recent improvements in automation is leading to reshoring, in which production is brought "back home" for labour-intensive manufacturing sectors, such as garment and footwear, electronics, and automotive, among others. ASEAN Member States are lagging in their responses to this trend. As aforementioned, the costs of these technologies are rapidly falling and their application is becoming more commonplace. Consequently, ASEAN could experience huge setbacks in development and growth if increased reshoring is not countered.

---

3 The ten ASEAN Member States include Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.

4 International Monetary Fund: World Economic Outlook Database (Oct. 2015); ILO and Asian Development Bank: A*SEAN Community 2015: Managing integration for better jobs and shared prosperity* (Bangkok, 2014).

5 Mobile phone penetration exceeds 100 per cent when there are more phones than people in circulation and use.

6 J. Woetzel et al.: *Southeast Asia at the crossroads: Three paths to prosperity* (McKinsey Global Institute, Nov. 2014).

7 ILO: *ASEAN in transformation: Perspectives of enterprises and students on future work* (Bangkok, 2016).

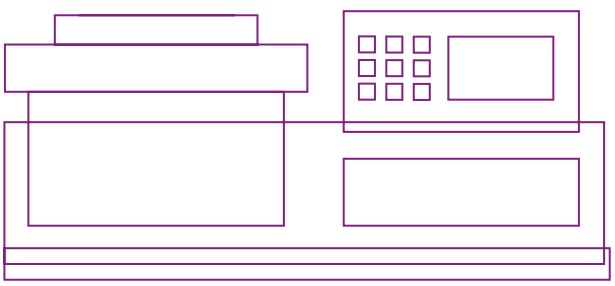
Currently, the ASEAN region has an opportunity to respond and capitalize on these technologies. Member States can augment existing work practices, extend the capabilities of workers, increase efficiency and productivity, generate new employment opportunities and even create novel industries. To achieve this, ASEAN policy-makers and enterprises need to actively consider technology when responding to changes in global and regional competition and pressures. Relatedly, deliberations are necessary to assess how ASEAN industries, enterprises and workforce will be reshaped when technologies are applied on a large scale.

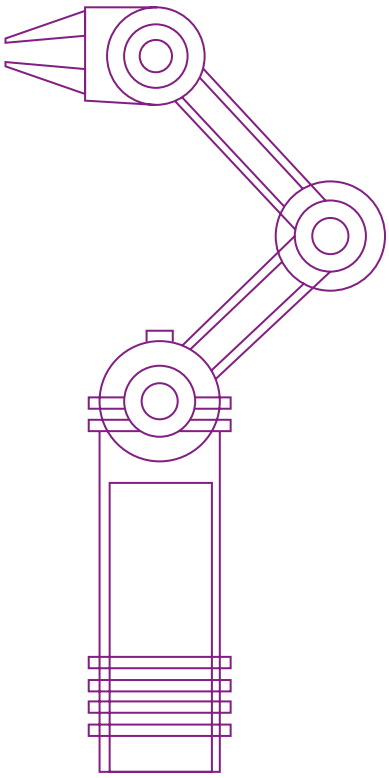
> "The United States is already looking into automated sewing and new technologies that bring us closer to the realities of inserting fabric at one-end of a machine and receiving a completed garment at the other end. This will alter the entire sector and create opportunities to take investment back to the States, possibly within the next five years."
>
> Source: Yuttana Silpsarnvitch, Secretary General, Thai Garment Manufacturers Association: Statement at ILO Experts Roundtable Consultation Meeting on Technology Transforming People and Jobs in ASEAN, Singapore, 18 Nov. 2015.

The risk of automation in ASEAN

To obtain a concrete understanding of how new technologies may disrupt major sectors in ASEAN and illustrate potential labour market impacts, the ILO Bureau for Employers' Activities (ILO-ACT/EMP), in collaboration with the ILO Regional Office for Asia and the Pacific (ILO-RO Asia and the Pacific) and national employers' organizations across the ASEAN region, conducted a broad-based study, assessing the factors influencing technology adoption, the rate of technology absorption, its impact on employment, and how enterprise are strategizing based on their current and future capacities. The selected sectors under examination are: automotive; business process outsourcing; electrical and electronic parts; garment and footwear; and retail.

The paper, *ASEAN in transformation: How technology is changing jobs and enterprises*, presents empirical evidence on the impact of technology in the workplace. It provides a ten-year projection of technology trends and industry changes until 2025, highlighting different enterprise responses. The paper also assesses career ambitions of ASEAN university and technical and vocational educational training (TVET) students to understand the future workforce's disposition and outlook on jobs, further providing policy-makers with a deeper understanding of the characteristics and aspirations of the incoming workforce. The research is based on two ASEAN-wide surveys, which collected primary data from over 4,000 manufacturing and services firms and 2,700 young people in 2015.





This technical paper, *The future of jobs at risk of automation*, comprises one document within the overall collection. The study assesses what types of occupations in the ASEAN region have a high probability of being automated by applying a research methodology developed by Carl Frey and Michael Osborne of the University of Oxford.[8] When this method was first implemented, the Frey and Osborne study estimated that 47 per cent of jobs in the United States were at high risk of computerization within two decades.[9] The same methodology has since been replicated for other industrialized and developing economies and uncovers similar, if not more dramatic, effects of automation risk to certain occupations.[10]

Five ASEAN countries – Cambodia, Indonesia, the Philippines, Thailand and Viet Nam – are analysed in this study. Combined, these five economies account for approximately 80 per cent of the entire ASEAN workforce.[11] The key findings in this study are:

- Approximately 56 per cent of all employment in the ASEAN-5 is at high risk of displacement due to technology over the next decade or two.
- Across the ASEAN-5 countries, prominent industries with high capacity for automation are hotels and restaurants; wholesale and retail trade; and construction and manufacturing.
- Industries with low automation risk across the ASEAN-5 include education and training, as well as human health and social work.
- Prominent occupations in certain countries face extreme risks of automation. For example, in Cambodia, where garment production dominates the manufacturing sector, close to half a million sewing machine operators face a high automation risk. In Thailand, automation risk is particularly acute for approximately 1 million shop sales assistants. In Indonesia, about 1.7 million office clerks are highly vulnerable to automation.
- In each of the ASEAN-5, women are more likely than men to be employed in an occupation at high risk of automation. Moreover, less educated workers and employees earning lower wages face higher automation risk.

Although the Frey and Osborne results should be understood with a few caveats (discussed in later sections of this paper), the findings presented in this paper nevertheless provide a useful benchmark to understand the extent to which human workers could be replaced with machines. The Frey and Osborne analysis also provides businesses, workers, jobseekers and policy-makers valuable insight into how different segments of a workforce will be affected by rapid advances in engineering. This can help spur actions addressing the need for innovative skills and workforce development. These issues are especially relevant for young people in school and those just now starting their professional lives. They will undoubtedly witness profound technological transformations during their working careers.

8 C. Frey and M. Osborne: *The future of employment: How susceptible are jobs to computerisation?* (University of Oxford, 2013).

9 Frey and Osborne define computerization as "job automation". Likewise, this technical paper interchangeably uses the terms computerization and automation. See C. Frey and M. Osborne, op. cit., p. 2.

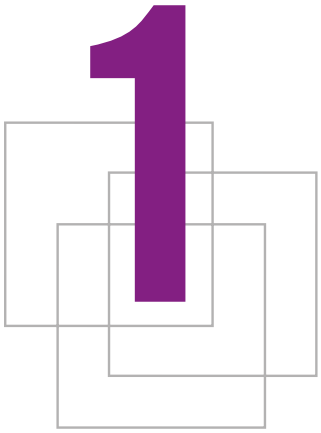
10 For example, see: Asian Development Bank: *Key Indicators for Asia and the Pacific 2015* (Manila, 2015); J. Bowles: "The computerisation of European jobs", 24 July 2014, http://bruegel.org/2014/07/the-computerisation-of-european-jobs/ [accessed 14 Dec. 2015]; Centre for Strategic Futures, Prime Minister's Office, Singapore: *Foresight 2015* (Singapore, 2015); Deloitte: *Agiletown: The relentless march of technology and London's response* (London, 2014). World Bank: *World Development Report 2016: Digital dividend*s (Washington, DC, 2016).

11 ILO and Asian Development Bank, op. cit., appendix table F1-3.

Figure 1. Key low- and high-risk occupations by employment in ASEAN-5

Source: Adapted from appendix 2, table A4 and figure 6.

METHODOLOGY AND DATA SOURCES



1.1 Conceptual and analytical framework

Existing studies have taken a task-based approach to evaluate jobs, analyse their links to technology and interpret the shifts in demand for that position.[12] These studies classify occupations along a spectrum of two attributes: routine versus non-routine and manual versus cognitive (see table 1). Occupations in which the bulk of tasks are more routine and follow explicit, codifiable procedures tend to be more adaptable to automation (quadrants A and C). By contrast, jobs resistant to computerization involve extensive non-routine, abstract tasks that require judgment, problem-solving, intuition, persuasion and creativity (quadrant D). Jobs that also resist automation are those with non-routine, manual tasks that demand a high degree of situational flexibility and human interaction (quadrant B). It is worth noting that occupations requiring primarily non-routine tasks and cognitive-intensive skills, such as doctors, may involve the occasional routine task. Therefore, categorization rests on the nature of predominant tasks required. In addition, it is worth noting that technology particularly complements jobs in quadrant D.

Table 1. Categorization of sample occupations by spectrum of tasks and skills

		Ease of automation	
		High (Routine tasks)	**Low (Non-routine tasks)**
Ease of complementarity	**Low (Manual-intensive skills)**	**A** Cashiers Typists Machine operators	**B** Landscapers Home health aides Security personnel
	High (Cognitive-intensive skills)	**C** Bookkeepers Proofreaders Clerks	**D** Doctors Lawyers Managers

Source: Authors' adaptation of D. Acemoglu and D. Autor, op. cit; World Bank, op. cit.

12 For example, see: D. Autor, F. Levy and R. Murnane: "The skill content of recent technological change: An empirical investigation", in *Quarterly Journal of Economics*, 118, November 2003, pp. 1279–1333; D. Acemoglu and D. Autor: "Skills, tasks and technologies: Implications for employment and earnings", in *Handbook of Labor Economics*, vol. 4, pp. 1043–1171.

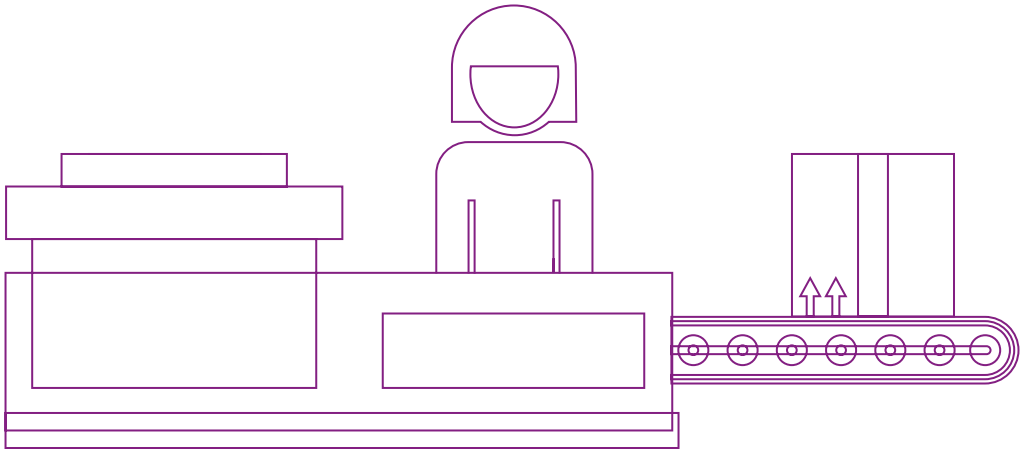
Because recent innovations in machine learning, mobile robotics and artificial intelligence allow machines to accomplish an expanding array of tasks, Frey and Osborne developed a seminal approach to quantify the extent to which occupations in the United States can be replaced by modern technology.[13] Frey and Osborne contend that nearly every occupation can be computerized in the next couple of decades, with the exception of those that involve high amounts of three broadly defined activities – creative intelligence, social intelligence, and perception and manipulation – that currently present automation bottlenecks. Frey and Osborne codify the probability of an occupation's automation in terms of the extent to which they require these three non-automatable tasks.

In order to formulaically classify occupations, Frey and Osborne used nine variables to characterize the three non-automatable activities:

- Perception and manipulation tasks: (1) Finger dexterity; (2) Manual dexterity; and (3) Cramped workspace, awkward positions
- Creative intelligence tasks: (4) Originality; and (5) Fine arts
- Social intelligence tasks: (6) Social perceptiveness; (7) Negotiation; (8) Persuasion; and (9) Assisting and caring for others.

Frey and Osborne subsequently evaluated 702 occupations drawn from a database developed by the United States Department of Labor, the online service O*NET, and calculated the probability of computerization for each occupation.[14] They concluded that around 47 per cent of total employment in the United States is at high risk of automation, with low-wage and low-skill occupations being particularly vulnerable.

This brief takes an identical approach to assess the automation of occupations in ASEAN, deploying the automation probabilities presented in the original Frey and Osborne study and applying them to the labour force survey data of Cambodia, Indonesia, the Philippines, Thailand and Viet Nam (see appendix 1 for detailed methodology). We also examine the econometric relationship between the risks of automation with two other factors: educational attainment and earnings. Furthermore, a standard logistic regression model quantifies the probability of being employed in a high-risk occupation for different socio-demographic indicators such as sex and age.

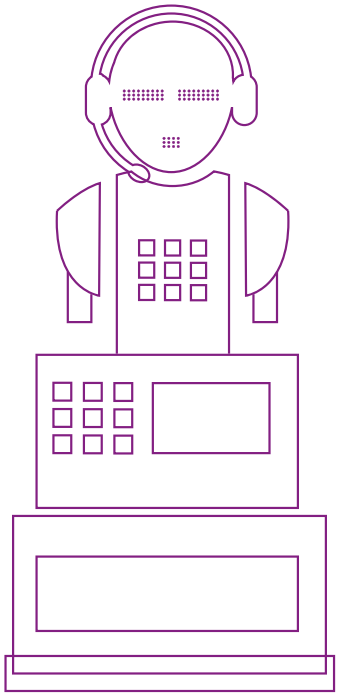


13 C. Frey and M. Osborne, op. cit.

14 The O*NET service and database is available at: www.netonline.org/ [accessed 14 Dec. 2015].

This study's results should be interpreted with a few caveats. Firstly, in ASEAN's developing economies, informal work arrangements and self-employment are commonplace. These workplaces are less likely to adapt in response to technology innovations because of capital investment constraints. Therefore, the brief presents the automation risks of the entire workforce and wage employees separately. The latter group is more likely to work in formal establishments that have the capacity to make business decisions related to technology and automation investments. Secondly, despite structural changes transforming ASEAN's labour market, the agricultural sector still remains a dominant employer for the countries examined in this study. The extremely routine and manual nature of agricultural work may put a higher share of workers in ASEAN's developing economies at high risk of automation relative to more industrialized economies.

Thirdly, lower wages and skill levels in ASEAN's developing economies may slow the process of workplace computerization. Despite rising wages, increases in productivity, falling technology costs and accelerations in technology application, the lower wage structures in the region may disincentivize workplace automation.[15] In addition, even in cases where automation is economically and financially justified, a lack of skilled workers with proper technical and digital competencies to operate, upgrade and maintain such technologies may deter automation. Together, these wage and skill dynamics are related to a fourth factor: the consequences of labour policies and institutions. For example, international migration policies, if poorly designed or enforced, may facilitate the reliance on low-wage workers and prolong low-value production. Consequently, this can discourage technology investments that can boost productivity and upgrade industries.



> "…it is largely already technologically possible to automate almost any task, provided that sufficient amounts of data are gathered for pattern recognition."
>
> Source: C. Frey and M. Osborne: *The future of employment: How susceptible are jobs to computerisation?* (University of Oxford, 2013), p. 23.

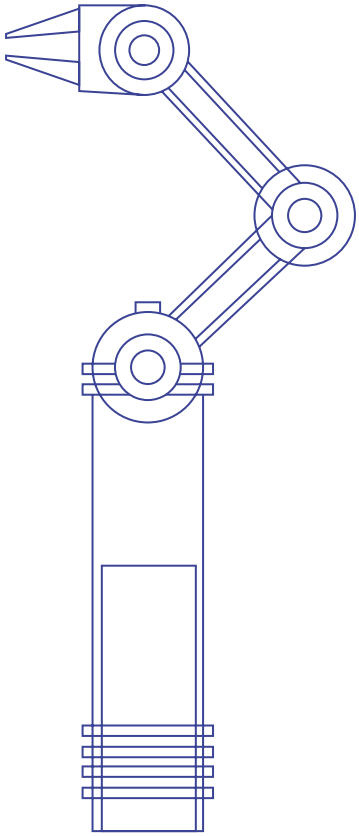
Fifthly, social factors specific to ASEAN businesses can offset the substitution effects of automation. For instance, the hotel and hospitality industry has often been cited as an industry prone to automation. However, hotel industry leaders in ASEAN have voiced the opposite. In 2015, ILO stakeholder interviews with hospitality representatives revealed that the demand for human services in the sector is actually increasing, and the sector still emphasizes "the human touch".[16] Despite the scientific possibility of extensive task automation, direct human interaction remains critical. The quality of person-to-person engagement produces competition among companies and is essential for creating a personalized experience that encourages repeated visits.

15 For further discussion on wage, productivity and skill development trends in ASEAN, see: ILO and Asian Development Bank, op. cit.

16 ILO: *ASEAN in transformation: Perspectives of enterprises and students on future work* (Bangkok, ILO).

"The adoption of technology in the hospitality industry is important but most critical to our business is customers. We find that majority of our customers prefer face-time. The hospitality industry is all about the human touch."

Source: Timothy Cheong, Group Human Resource Director, Banyan Tree Singapore: Statement at joint ILO-Singapore National Employers Federation Executive Dialogue on Technology Changing the Face of Business in ASEAN, Singapore, 17 Nov. 2015



Lastly, the methodology does not attempt to predict the precise number of jobs that will be automated or displaced, nor does it identify an exact year when this will happen. Instead, it identifies the occupations and types of workers facing a high probability of automation over the next couple decades based on the nature of tasks involved. Some studies contend that the future of work will be less about technology displacing humans and more about a complementarity between humans and technology in the workplace.[17] Even in this scenario, the workplace will undergo significant technological changes and many conventional jobs will be redefined.

1.2 Background statistics

Before presenting the findings, it is useful to understand the labour markets of the five ASEAN countries (see appendix 2).[18] In total, the number of workers for which an automation probability estimate could be generated is nearly 244.2 million, ranging from 7.1 million in Cambodia to 107.6 million in Indonesia. In Cambodia and Viet Nam, the workforce is distributed rather evenly between women and men. In Thailand, men comprise 55 per cent all workers. By contrast, gender disparities in employment are more prominent in both Indonesia and the Philippines. In these cases, men account for more than 60 per cent of employment.

"Technological changes are welcomed because it replaces mundane tasks and enable the organization to upskill its workforce for higher value-add contributions."

Source: Kelly Sofian, Senior Director of Quality and Human Resources, Silicon Manufacturing Company: Statement at ILO Experts Roundtable Consultation Meeting on Technology Transforming People and Jobs in ASEAN, Singapore, 18 Nov. 2015.

17 For example, see: D. Autor: *Polyani's paradox and the shape of employment growth*, Draft paper prepared for the Federal Reserve Bank of Kansas City Economic Policy Symposium on Re-Evaluating Labor Market Dynamics, Jackson Hole, Wyoming, 21-23 Aug. 2014.

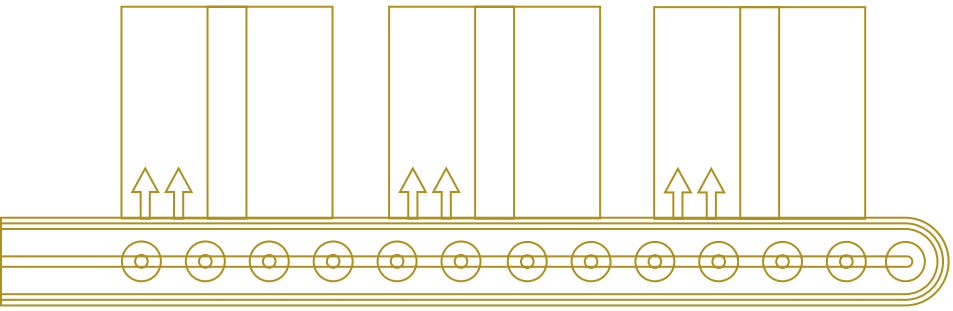
18 These statistical insights are based on official national labour force survey data for Cambodia (2012), Indonesia (August 2010), the Philippines (October 2013), Thailand (Quarter 3, 2013) and Viet Nam (2013). For further discussion of historical trends in the ASEAN labour market, see ILO and Asian Development Bank, op. cit.

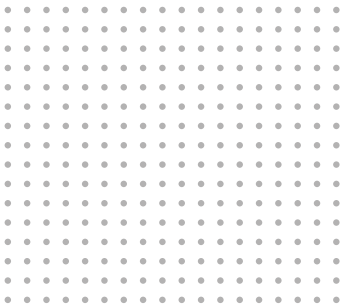
In terms of age composition, Cambodia stands out with the lowest average workforce age (34.6 years). In comparison, the mean age for workers in the other four countries ranges from 38 years to 41 years. The shares of young people between 15 and 24 years of age also vary across the five countries. In Cambodia, the percentage is the highest (29 per cent), followed by the Philippines (19 per cent). By contrast, the share is merely 11 per cent in Thailand, reflecting the country's ageing demographic.

Human capital indicators also reveal some variances (see figure 2). In Cambodia, merely one in ten of workers captured in the sample completed secondary schooling, or some post-secondary education. In Viet Nam, the comparable share of secondary school graduates is only around one in four. In both Indonesia and Thailand, it's around one in three. In contrast, the Philippines workforce exhibits higher educational attainment: nearly three in five are secondary school graduates or have post-secondary schooling. Moreover, across the five countries, only in the Philippines does high-skill employment as a manager, professional or technician exceed 20 per cent.[19] In Thailand, the share is 14 per cent and only around 9 to 10 per cent in Cambodia, Indonesia and Viet Nam. In addition, among the three countries with available information on job experience, workers in Indonesia, on average, tend to have more experience working with the same employer. There, 57 per cent have ten or more years of job experience, compared with 41 per cent in Viet Nam and only 20 per cent in Cambodia. This could partly reflect lower workplace turnover as a result of not only better employer-provided incentives, but also the specificities of national labour legislation.[20]

When looking at the main economic sectors, agriculture stands out as a predominant employer, accounting for approximately one third (the Philippines) to nearly one half (Viet Nam) of total employment. Manufacturing, an industry commonly discussed in the context of technology and automation, is also a key sector of employment. In Cambodia, it accounts for approximately 18 per cent of employment and 14 per cent in the Thailand and Viet Nam. By contrast, manufacturing employs only 8 per cent of the workforce in the Philippines. With regard to services, wholesale and retail trade are the leading subsectors, and one that faces significant automation probabilities. Across the five countries, the sector comprises from 13 per cent (Viet Nam) to 19 per cent (the Philippines) of all workers.

Finally, self-employment dominates the ASEAN-5. Wage workers account for less than half of all employment in four of the five countries. The only exception is the Philippines, in which nearly three in five of those employed are in a salaried job.



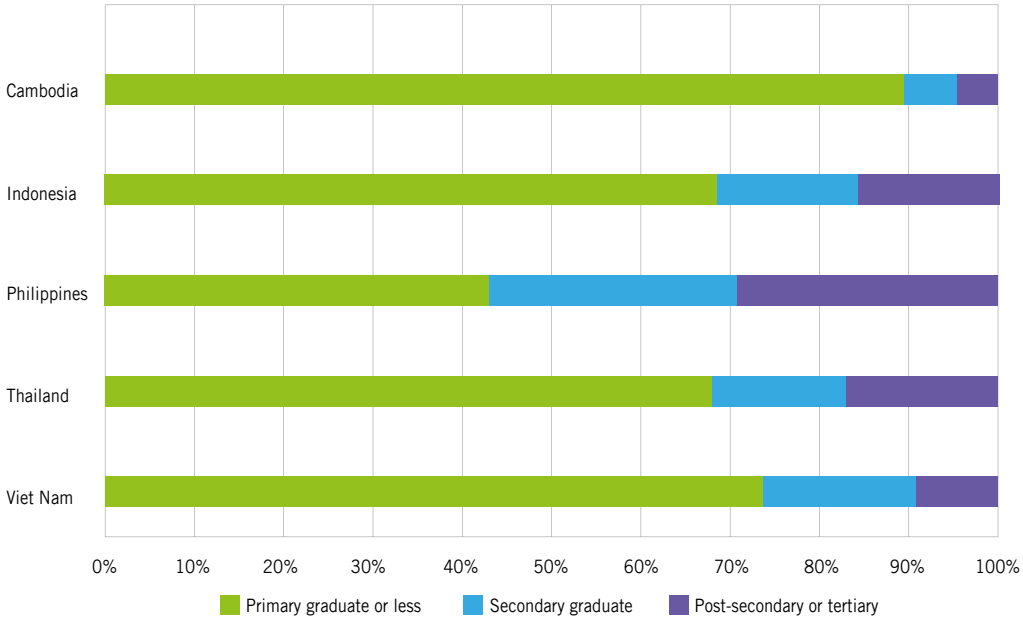


19 For further discussion of the categorization of low-skill, medium-skill and high-skill occupations, see: ILO: *International Standard Classification of Occupations: Volume 1: Structure, group definitions and correspondence tables* (Geneva, 2012).

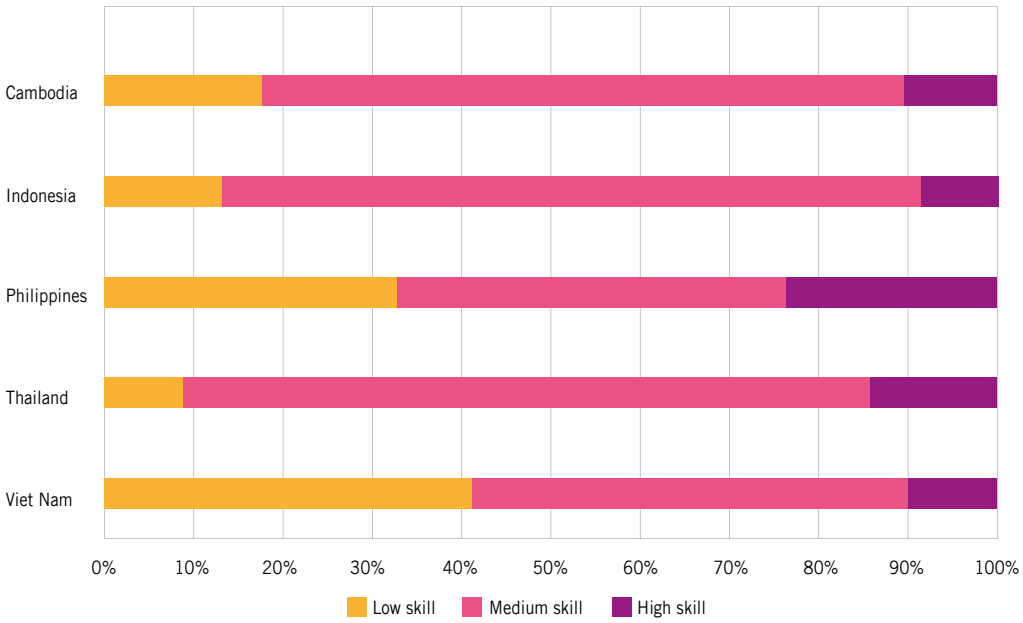
20 For example, this could include legislation regarding compensation costs for retrenchment or dismissal.

Figure 2. Distribution of employment by education and skill level (per cent)

Education



Skill level



Note: Includes workers aged 15 and above. High skill occupations are defined as ISCO groups 1 (managers), 2 (professionals) and 3 (technicians and associate professionals); medium-skill occupations include ISCO groups 4 (clerks), 5 (service and sales workers), 6 (skilled agricultural and fishery workers), 7 (craft and related trade workers) and 8 (plant and machine operators and assemblers); and low-skill occupations consist of ISCO group 9 (elementary occupations).
Source: Same as appendix 2 table A.1.

KEY FINDINGS

2

Key finding 1: Nearly three in five jobs face a high risk of automation

For the ASEAN-5 (Cambodia, Indonesia, the Philippines, Thailand and Viet Nam), around 56 per cent of all employment has a high risk of automation in the next couple decades (see figure 3). However, the risks of automation differs widely across the countries. Among the ASEAN-5, the share of jobs with a high probability of automation is lowest in Thailand (44 per cent) and highest in Viet Nam (70 per cent). In the Philippines, Indonesia and Cambodia, the shares are 49 per cent, 56 per cent and 57 per cent, respectively. The differences in the labour market structures of each country produces these variations. For example, in Viet Nam, where the share of low-skilled elementary occupations in total employment (around two in five) is the highest among the five ASEAN country samples, the overall probability of computerization is also the most pronounced. On the contrary, the Thailand labour market exhibits the smallest share of low-skill employment (less than one in ten).

Among wage and salaried workers, who are more likely to work in establishments with the capacity to be early adopters of new technologies, around 56 per cent face a high probability of automation (see figure 4). In Thailand and Viet Nam, the prevalence is lower, around 51–52 per cent. Conversely, only in Cambodia does the risk of automation for wage earners (68 per cent) differ significantly from the ASEAN-5 estimate. This could reflect the relatively less diversified nature of the Cambodia economy and labour market. Of the country's 3.3 million wage employees, 1.8 million (54 per cent) are concentrated in just three sectors: agriculture, garment manufacturing and construction. All three industries tend to be highly susceptible to technological substitution.

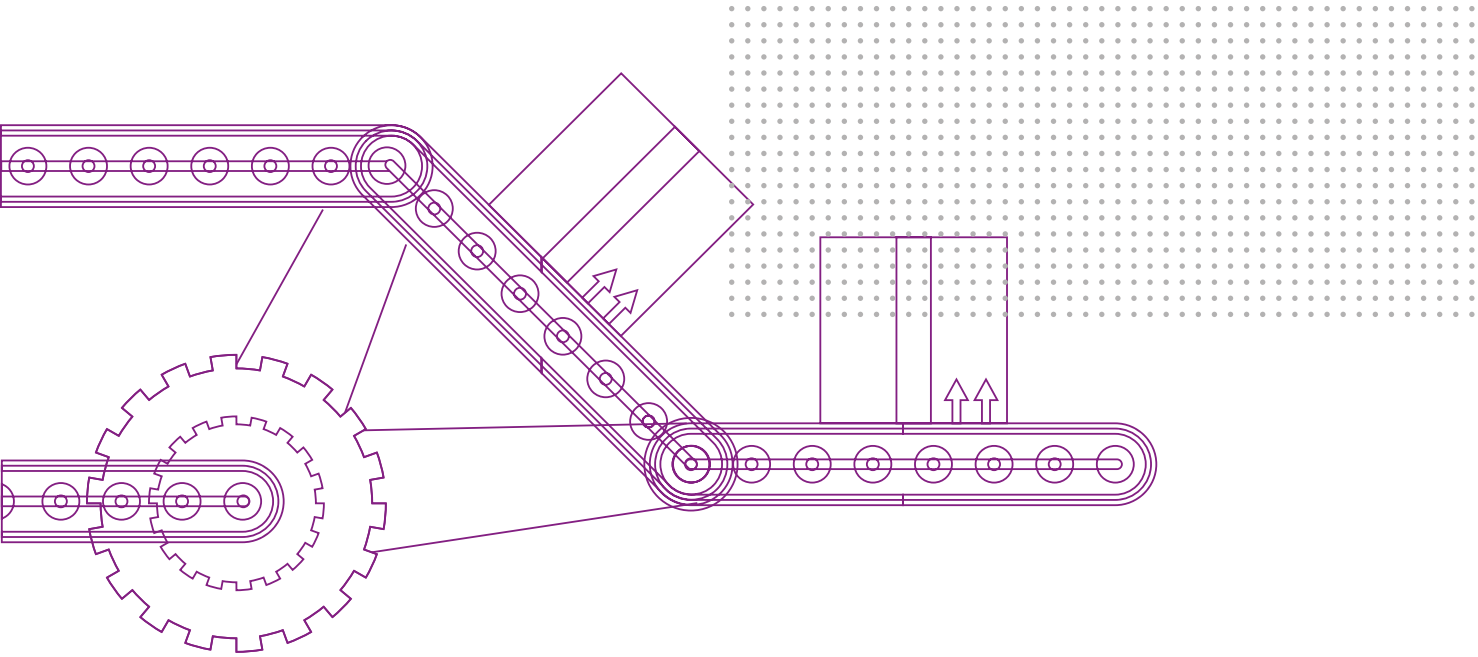
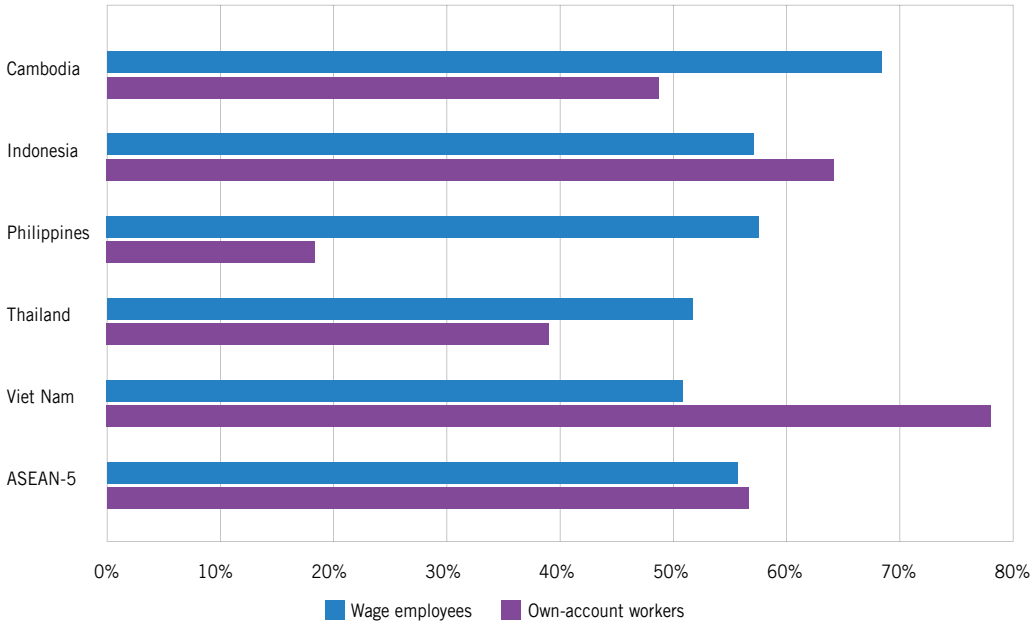


Figure 3. Distribution of employment at risk of automation

Note: Includes workers aged 15 and above. ASEAN-5 represents the aggregate total of Cambodia, Indonesia, the Philippines, Thailand and Viet Nam. Automation risk categorized by low (less than 30 per cent), medium (30 per cent to 70 per cent) and high (exceeds 70 per cent) probability. Includes non-military employment for which a probability of automation could be estimated. Survey sampling weights applied.

Source: Same as appendix 2 table A.1.

Figure 4. Share of wage employees and own-account workers at high risk of automation (per cent)

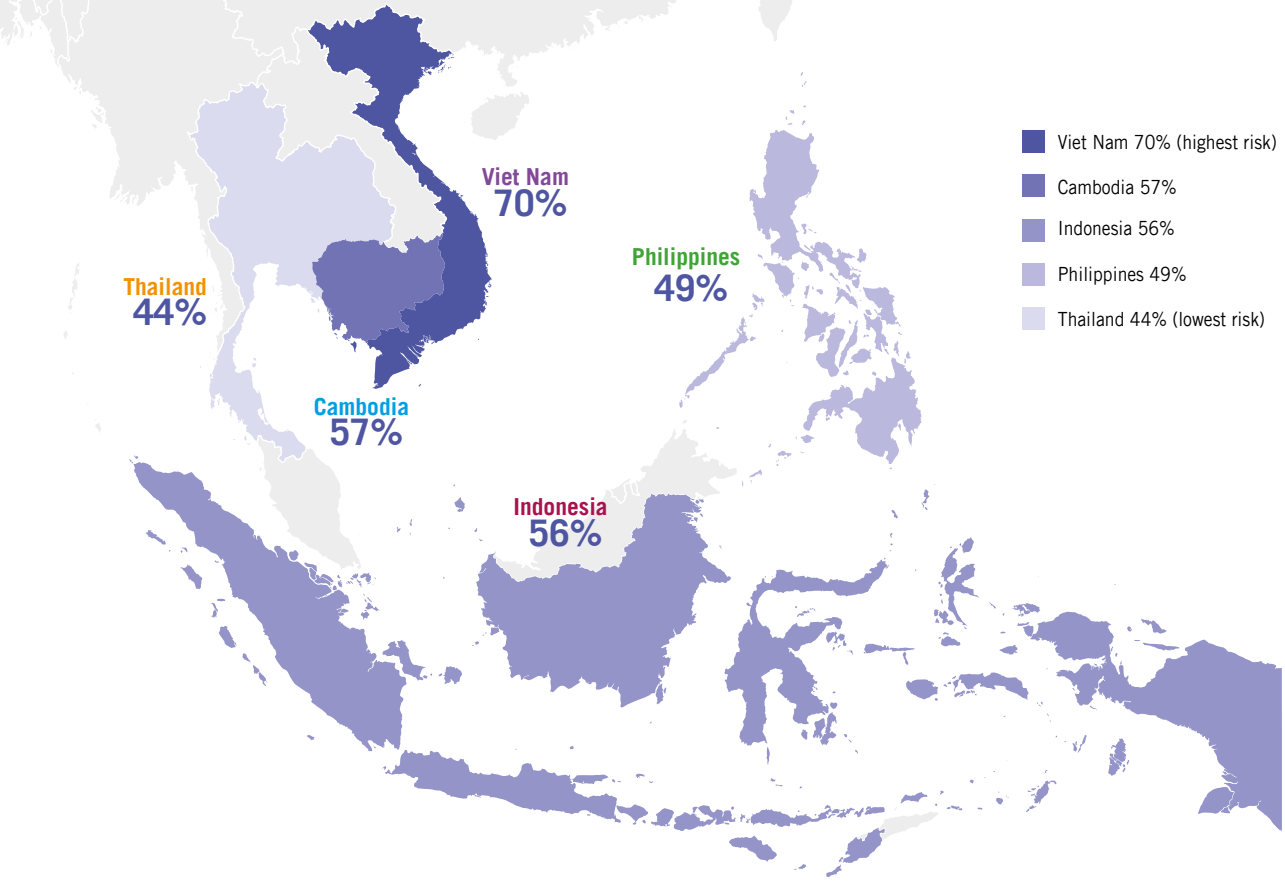


Note: Includes workers aged 15 and above. ASEAN-5 represents the aggregate total of Cambodia, Indonesia, the Philippines, Thailand and Viet Nam. High risk categorized as exceeding 70 per cent automation probability. Includes non-military employment for which a probability of automation could be estimated. Survey sampling weights applied.
Source: Same as appendix 2 table A.1.

Compared with wage employees, the automation risks for self-employed, or own-account, workers is only marginally higher when looking at the ASEAN-5 overall (57 per cent). Although, this overall figure is heavily shaped by the high automation risks in Indonesia (64 per cent) and Viet Nam (78 per cent). By contrast, the risk of automation among own-account workers is significantly lower than for wage earners in Cambodia (49 per cent), the Philippines (19 per cent) and Thailand (39 per cent). These country-specific trends hold true when controlling for differences in various social and demographic variables (discussed later).

Across each of the ASEAN-5 countries, several common occupations account for a sizeable share of employment and also are highly vulnerable to automation (see appendix 2, table A.4). For example, around 27 million subsistence farmers and low-skilled crop farm labourers in the five countries fall into the high-risk category of technology substitution, as do nearly 23 million street vendors, stall and market salespersons. Likewise, almost 5 million low-skilled construction labourers face a high risk. On the other end of the spectrum, key occupations with a low risk of automation in the majority of the ASEAN-5 countries include school teachers (6.5 million) and handicraft workers in wood and basketry (1.1 million).

Figure 5. Percentage of wage workers at high risk of automation in ASEAN-5

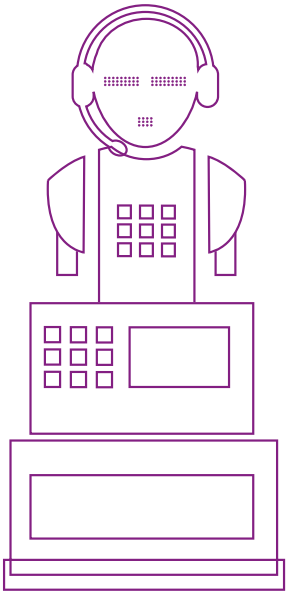


Source: Same as appendix 2 table A.1.

A number of prominent occupations specific to each country also have a high probability of computerization. In Cambodia, where garment production dominates a relatively undiversified manufacturing sector, the nearly half a million sewing machine operators face an automation risk of 89 per cent. In Indonesia, other key occupations at high risk include gardeners (9.1 million), shop salespersons (1.8 million) and tailors (1.1 million). In the Philippines, which has the lowest share of agricultural and manufacturing employment among the ASEAN-5, those working as fishery labourers (580,000), waiters (574,000), carpenters (525,000) and office cleaners (463,000) face a high potential of automation. In Thailand, the automation risks are notably acute for almost 1 million shop sales assistants, 624,000 food service counter attendants, 606,000 cooks and more than 800,000 combined office clerks and accounting associate professionals. In Viet Nam, notable high risk occupations also include shop sales assistants (2.1 million), garden labourers (1 million) and sewing machine operators (770,000).

Key finding 2: Technology will shape the future of manufacturing and services

The potential for technology substitution varies widely across different economic sectors (see appendix 2, table A.3). For the ASEAN-5 as a whole, key industries with high capacity for automation include hotels and restaurants (80.7 per cent), wholesale and retail trade (77.5 per cent), construction (70.8 per cent) and manufacturing (61.6 per cent). However, the risk of automation for a particular industry differs substantially from country to country. This is driven in part by the structure of the specific industry in each country and the skill level of jobs in that sector. For example, the share of employment classified as having a high risk of automation in agriculture is nearly three-fifths for the ASEAN-5, but ranges from around one third in Thailand to more than four-fifths in Viet Nam. The wide variance highlights thecomparatively more sophisticated nature of Thailand's agricultural production. In Thailand, low-skill, elementary occupations make up less than six per cent of agricultural employment. By contrast, the share is nearly 74 per cent in Viet Nam.



"It's unlikely for companies in the food processing industry to introduce labour-intensive processes in the future. Technology is extremely important in our industry from a quality and safety perspective. Apart from the final packing process, most steps are fully automated with no manual alternatives. To automate packing, we need people who can trouble shoot and problem-solve with new technology; however, these skills are currently difficult to source locally."

Source: David Calver, Regional Operations Director for Thailand and China, Associated British Foods and Beverages Ltd. (Thailand) ILO interview, 10 Nov. 2015.

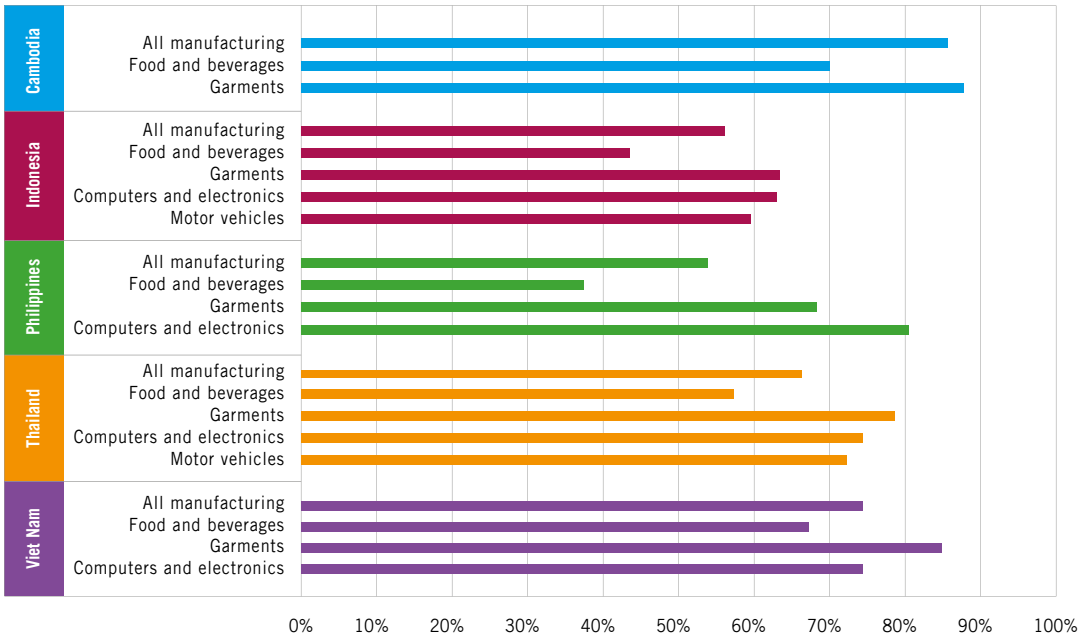
Given the importance of technology adaptation in manufacturing and services, figure 4 presents the share of wage employees in key manufacturing and services subsectors at high risk of automation. Wage and salaried earners (relative to own-account workers) are more likely to be employed in formal establishments with the financial and human resources to invest in technology and automation. Therefore, these findings focus on those workers in industries likely to face the early impacts of workplace automation. In Cambodia, the share of manufacturing wage employment facing a high risk of automation is 86 per cent. In Viet Nam, the share is 75 per cent. In Indonesia, the Philippines and Thailand the shares are considerably lower (54–67 per cent).

Garment, textile and footwear production are major subsectors that make manufacturing overall so vulnerable to automation. For the ASEAN-5, it employs three out of every ten wage employees in manufacturing, with the ratio as high as three in four in Cambodia and two in five in Viet Nam. Garment, textile and footwear production in ASEAN are strongly characterized by low-skill and labour-intensive production. This is especially the case in Cambodia and Viet Nam. In Indonesia, the Philippines and Thailand, garment manufacturing is more developed and has shifted further up the value chain, but production still remains primarily at the low value end.[21] Given that the bulk of salaried jobs in the sector (such as sewing machine operators) require completing extensive routine and manual tasks, the large shares of garment wage workers at high risk of automation is unsurprising, ranging from 64 per cent in Indonesia to 88 per cent in Cambodia.

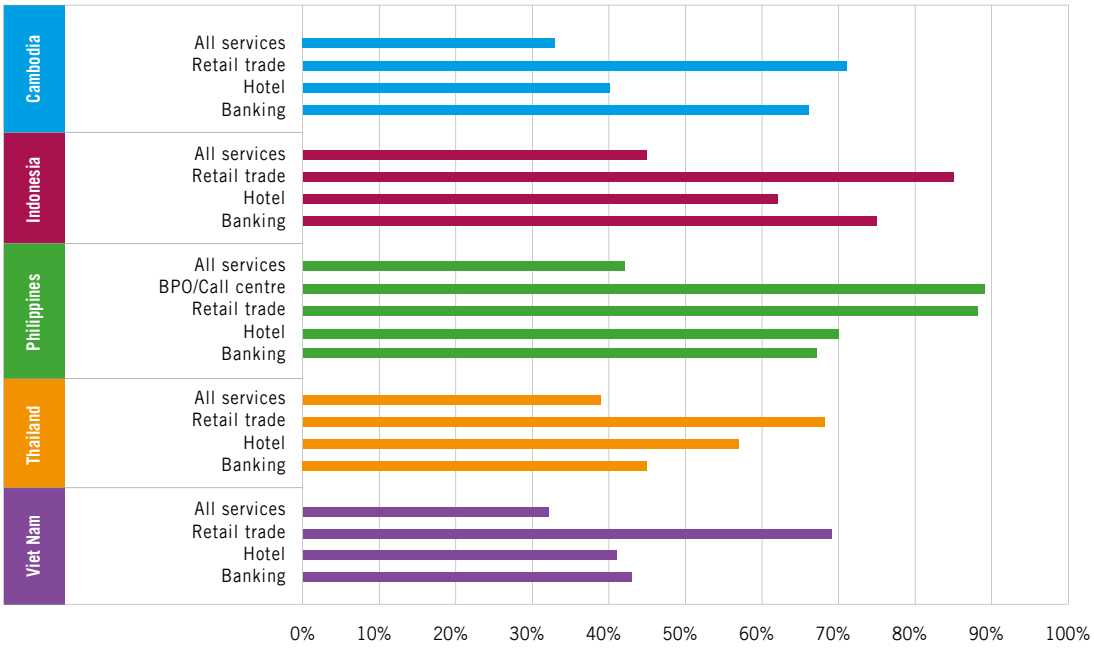
[21] For further discussion on the Asia garment industry including comparative statistics on labour productivity, wages and skill levels: see: P. Huynh: *Employment, wages and working conditions in Asia's garment sector: Finding new drivers of competitiveness*, ILO Asia-Pacific Working Paper Series (Bangkok, ILO, 2015).

Figure 6. Share of wage and salaried employment in key manufacturing and services subsectors at high risk of automation (per cent)

Manufacturing



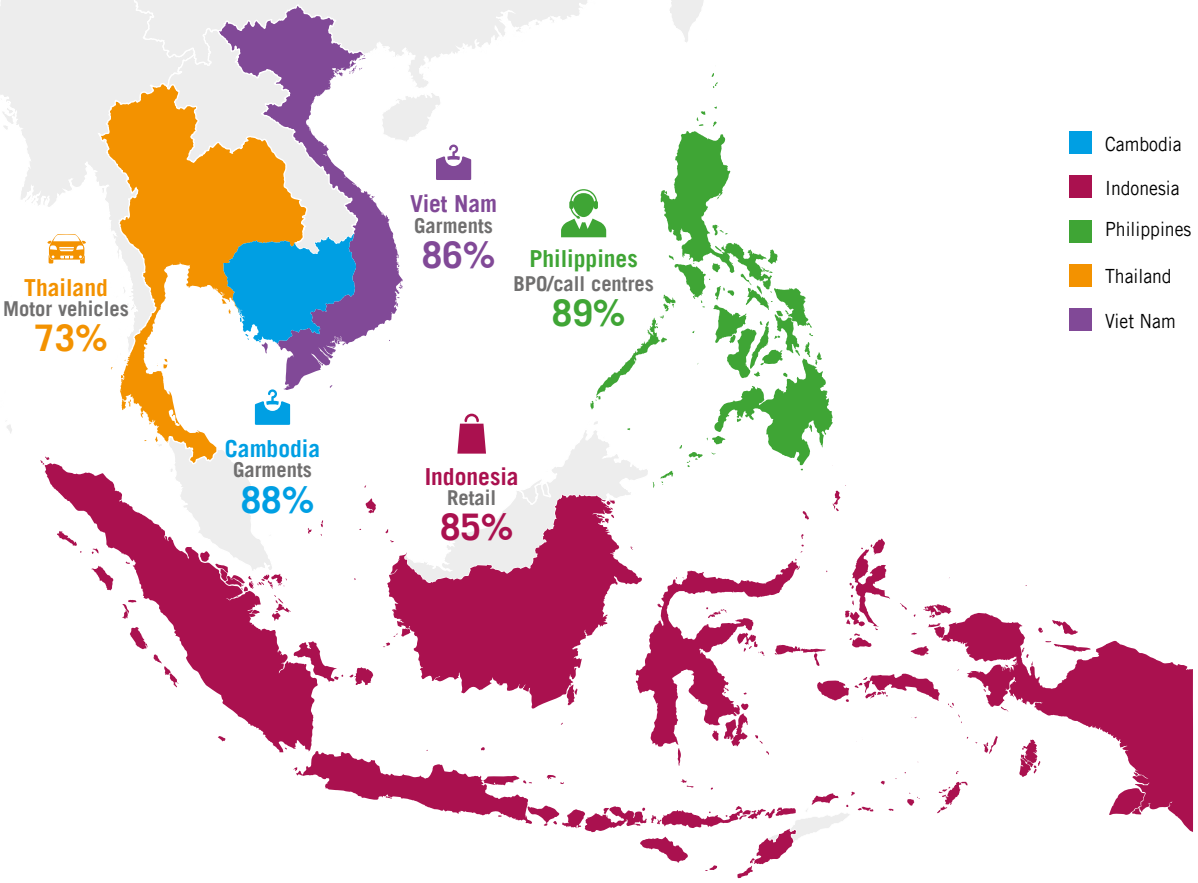
Services



Note: Includes workers aged 15 and above. Manufacturing and services subsectors correspond to the following divisions of the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4: food and beverage (10 and 11); garment, textiles and footwear (13, 14 and 15); computer and electronics (26); motor vehicles and accessories (29); retail trade (47); hotels (55); banking and financial services (64) and call centre activities (822). High risk includes non-military occupations with a probability of automation that exceeds 70 per cent. Survey sampling weights applied.

Source: Same as appendix 2 table A.1.

Figure 7. Percentage of wage workers at high risk of automation in key sectors within ASEAN-5

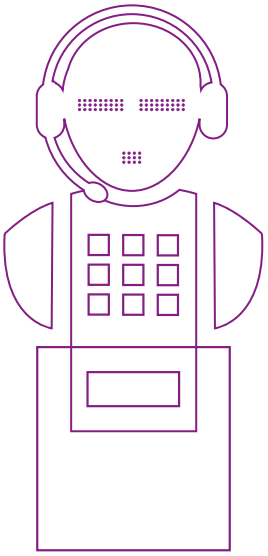


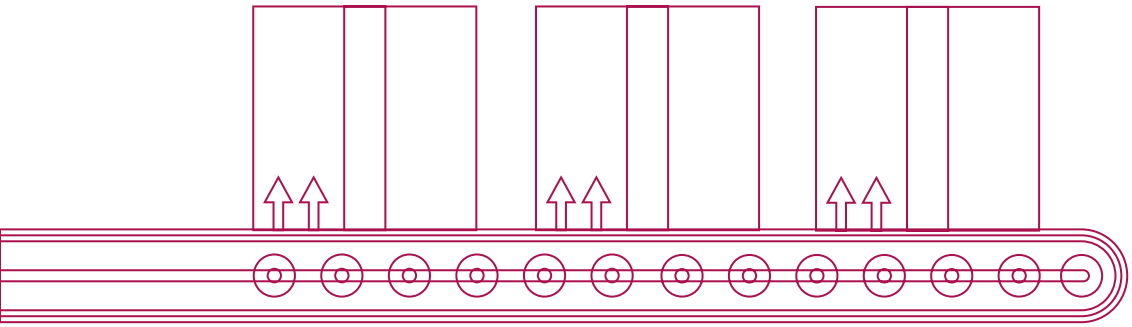
Source: Adapted from appendix 2, table A4 and figure 6.

Food and beverage production is another important manufacturing subsector in the ASEAN-5. It contributes 30 per cent of all manufacturing salaried jobs in the Philippines, 21 per cent in Thailand, 18 per cent in Indonesia, and 15 per cent in Viet Nam. Across the five countries, the share facing a high capacity for automation varies widely, from 37 per cent in the Philippines to 70 per cent in Cambodia. These differences, again, are driven by differences in the skill and occupational compositions of the food and beverage production in each country. In the Philippines, for example, butchers and bakers fall into the high risk category of automation but account for only around 15 per cent of all wage employment in the subsector. By contrast, in Cambodia, they make up more than 50 per cent.

While manufacturing in ASEAN's developing economies primarily focuses on lower value products, computer and electronics do make up 10 per cent of all salaried, manufacturing employment in Thailand and 15 per cent in the Philippines. Likewise, motor vehicle production employs 7 per cent of all manufacturing wage workers in Thailand. Although their employment content is relatively lower, these subsectors are vital for facilitating higher value manufacturing within global production systems. The predominant occupation in the computer and electronics industry are electronic equipment assemblers, accounting for nearly 58 per cent and 70 per cent of all salaried employment in the sector in Thailand and the Philippines, respectively. These jobs face an extremely high probability of automation (92 per cent) given the rapid penetration and advancements in robotic technologies.[22] Motor vehicle production in Thailand, where one in three wage workers are high-risk mechanical machinery assemblers, faces a similar outlook.

Compared with manufacturing, the services sector in the ASEAN-5 faces considerably lower automation risks. The share of salaried employees in services that fall into the high risk group for automation ranges from one third in Cambodia and Viet Nam to slightly more than two-fifths in Indonesia. However, the share of wage workers at high risk of automation is significantly higher in the retail sector in all five economies and the hotel industry in Indonesia, the Philippines and Thailand. Ultimately, technology will affect the 4.3 million salaried salespersons and assistants who make up three-fifths of all wage employment in the retail sector. This projection is corroborated by the emergence of online retailing and e-commerce in the region.[23] For the hotel industry, high automation risks underscore the potential vulnerability of hotel receptionists and cleaners, although the adoption of technology may allow for greater focus on social intelligence tasks associated with managing client relations and improving customer service, as opposed to outright labour displacement. In Cambodia, Indonesia and the Philippines, a large share of wage workers in the banking sector also face high automation risks. In particular, bank tellers and accountants, who make up a substantial share of salaried employment in the industry, may be among those initially impacted by workplace automation. In the Philippines, around 89 per cent of salaried workers in the vital business processing outsourcing (BPO) sector fall into the high risk category of automation.[24]



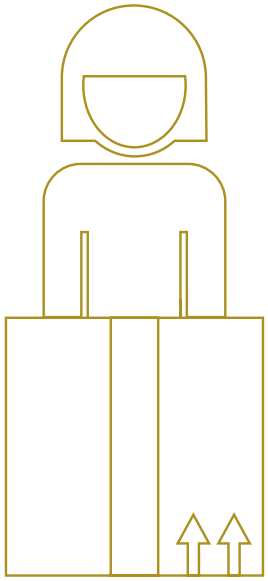


22 Annual shipments of industrial robots to Thailand are projected to increase from 4,200 units in 2015 to 7,500 units in 2018. See: *International Federation of Robotics: World Robotics: Industrial Robots 2015* (Frankfurt, 2015).

23 For further discussion on the growth and potential of e-commerce in ASEAN, see: A.T. Kearney and CIMB ASEAN Research Institute: *Lifting the barriers to e-commerce in ASEAN* (Singapore, 2015), www.atkearney.com/documents/10192/5540871/Lifting+the+Barriers+to+ecommerce+in+ASEAN.pdf/d977df60-3a86-42a6-8d19-1efd92010d52 [accessed 24 Dec. 2015].

24 The automation estimate includes only employment in call centres. For further discussion on potential technology impacts on this sector in the Philippines, see: The Economist: "The end of the line", 6 Feb. 2016, http://www.economist.com/news/international/21690041-call-centres-have-created-millions-good-jobs-emerging-world-technology-threatens [accessed 26 Feb. 2016].

Key finding 3: Women, workers with less education and workers in lower-wage occupations are more likely to be impacted

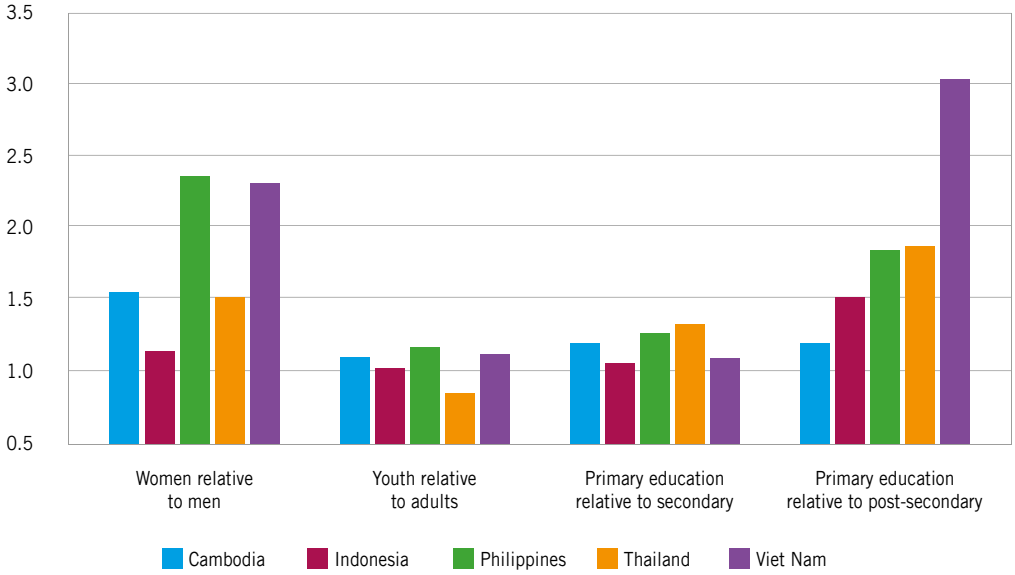


To extend insights beyond the main occupations and sectors at risk of automation, several socio-demographic indicators are analysed to further understand how workplace automation affects different segments of the ASEAN workforce. Employing a standard logistic regression model that controls for variances in sex, age, marital status, education, job experience, in-country locality, status of employment and economic sector, there is strong evidence that certain workers are more prone to technology impacts (see figure 8). In each of the ASEAN-5, women are more likely than men to be employed in an occupation at high risk of automation. The highest odds for women are in the Philippines and Viet Nam, where their probability of being in a high risk occupation is around 2.3 to 2.4 times as high as their male counterparts. In Indonesia and Thailand, women are 50 to 60 percent more likely to occupy a high-risk job compared to men. In Cambodia, women also face greater odds of being in high-risk jobs than men, albeit by a relatively smaller margin (20 per cent higher). In four of the countries, young workers aged 15–24 are slightly more susceptible to having an occupation at high risk relative to adult workers, although the age-based disparity is considerably lower than the gaps by sex. In the case of Thailand, which is the only country of the five that is already facing an ageing demographic profile, adult workers are more vulnerable than youth.[25]

Education levels also produce significantly different odds of occupying a high risk job. For workers with only a primary degree or less, the probability of being at high risk of computerization is 10–30 per cent higher than for secondary school graduates. When comparing primary school educated workers against those with post-secondary or tertiary schooling, the probability ratios spike substantially. In Indonesia, for example, primary school graduates are 50 per cent more likely to be at high risk compared with those with post-secondary education. In the Philippines and Thailand, the odds are around 90 per cent higher. In Viet Nam, those who have only completed primary school are astoundingly 3.1 times more likely to be in a high risk occupation. These trends tend to support the notion that higher education and training helps develop the competencies needed for complicated tasks requiring advanced levels of perception and manipulation, creative intelligence, and social intelligence – the tasks considered difficult to automate. It also substantiates warranted concerns regarding the low level and low quality of post-secondary education, tertiary education and training in ASEAN's developing economies, as well as the generally low education attainment levels among the workforce. As noted earlier, in Cambodia, merely one in ten workers has completed secondary schooling or has some post-secondary education. In Viet Nam, the ratio of secondary school graduates is only around one in four and in Indonesia and Thailand, around one in three.

[25] As discussed earlier, Thailand's ageing workforce is reflected in both its higher average age and the greater share of adults in total employment (see appendix 2, table A.1).

Figure 8. Probability of occupying a high-risk, automatable job by gender, age and education levels



Note: Indicates the relative probability of being employed in an occupation at high risk of automation for (a) women aged 15 and above relative to men aged 15 and above; (b) youth aged 15-24 relative to adults aged 25 and above, (c) workers aged 15 and above with a primary education or less relative to those with a secondary degree and those with post-secondary or tertiary studies, based on logistic regressions that control for differences in sex, age, marital status, education, experience, geographic location, status of employment and economic sector. A value of 1 represents equal likelihood of being employed in a high risk occupation. High risk includes non-military occupations with a probability of automation that exceeds 70 per cent. Survey sampling weights applied.

Source: Appendix 2 table A.5.

These results are further corroborated when looking at the relationship between the probability of automation and the average level of educational attainment for each individual occupation in the ASEAN-5 (see appendix 3, figure A.1). There is clearly a strong inverse correlation between the two. Less educated workers face higher automation risks in all five countries, with the results for Viet Nam being the most pronounced. Given the established link between higher education and better wages, it is unsurprising that a similar association exists between average earnings and computerization risks (see appendix 3, figure A.2). In all five countries, having lower average wages equates to facing higher probabilities of automation. In other words, higher paid jobs are less prone to automation. Together, these findings reveal a strong negative correlation between both education and wages with automation risks and are similar to the results presented in the original Frey and Osborne study.

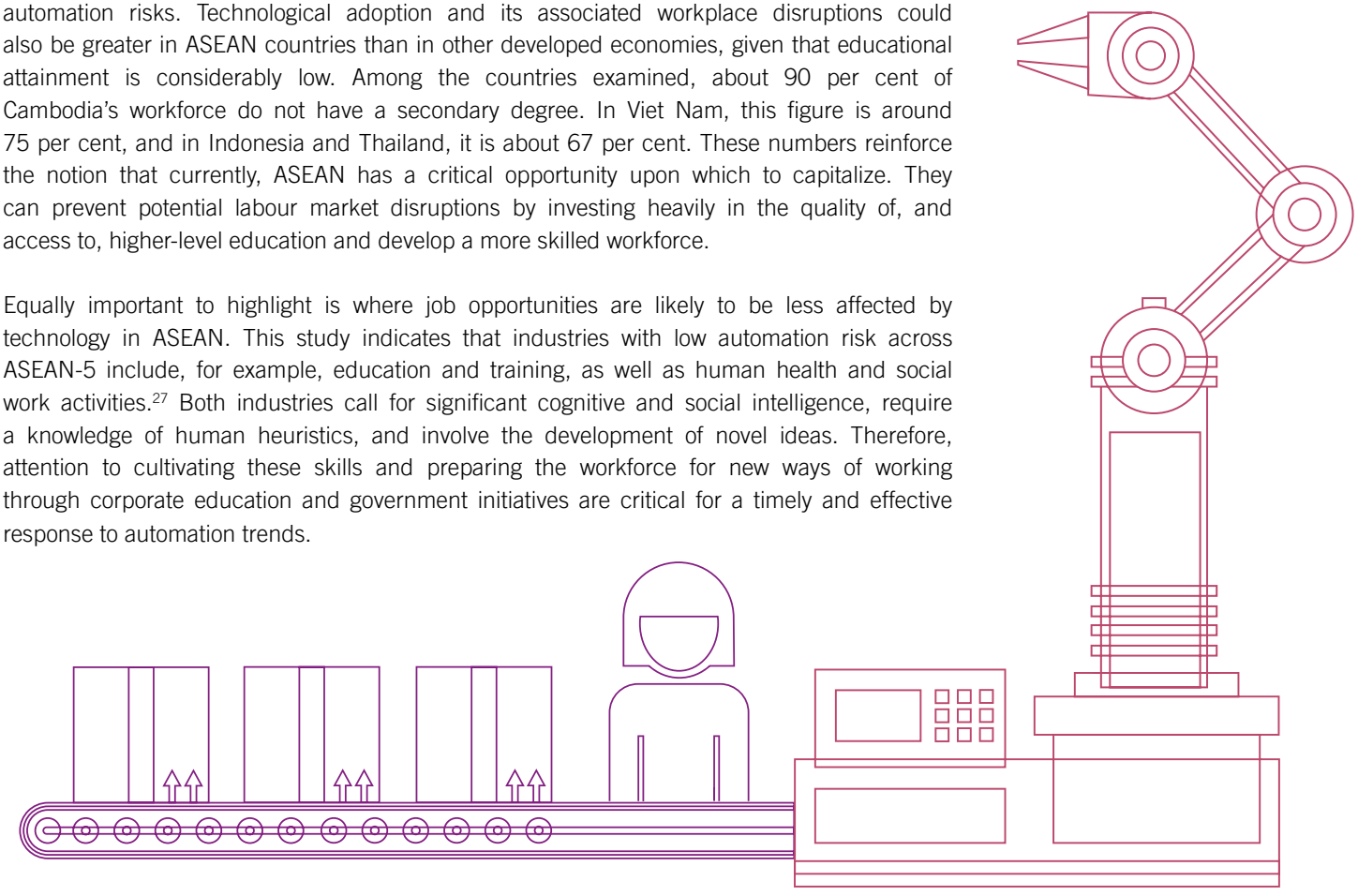
CONCLUSION

3

3.1 ASEAN has considerable automation opportunities and threats

A common trend surfaces across all countries – developing or developed – where the Frey and Osborne methodology has been replicated. Low-wage jobs and workers with low educational attainment face greater automation threats. Other studies on technology and workplace automation in developing countries suggests that the proportion of threatened jobs is much greater in developing economies.[26] The greater vulnerability for developing economies appears to be a consequence of having relatively more jobs that are less skilled and thus easily automatable.

The study's examination of the ASEAN-5 countries, in which 56 per cent of jobs are at high risk of automation, reinforces these findings. Workers engaged in the hotel and restaurant; wholesale and retail trade; and construction and manufacturing industries have the greatest automation risks. Technological adoption and its associated workplace disruptions could also be greater in ASEAN countries than in other developed economies, given that educational attainment is considerably low. Among the countries examined, about 90 per cent of Cambodia's workforce do not have a secondary degree. In Viet Nam, this figure is around 75 per cent, and in Indonesia and Thailand, it is about 67 per cent. These numbers reinforce the notion that currently, ASEAN has a critical opportunity upon which to capitalize. They can prevent potential labour market disruptions by investing heavily in the quality of, and access to, higher-level education and develop a more skilled workforce.

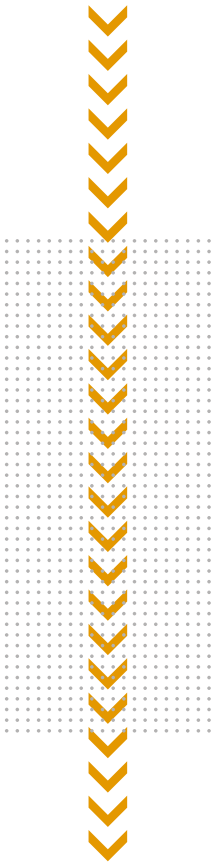


Equally important to highlight is where job opportunities are likely to be less affected by technology in ASEAN. This study indicates that industries with low automation risk across ASEAN-5 include, for example, education and training, as well as human health and social work activities.[27] Both industries call for significant cognitive and social intelligence, require a knowledge of human heuristics, and involve the development of novel ideas. Therefore, attention to cultivating these skills and preparing the workforce for new ways of working through corporate education and government initiatives are critical for a timely and effective response to automation trends.

26 World Bank, op. cit.

27 The transport industry also has a relatively lower overall risk, but this should not discount the emerging scientific advances in driverless motor vehicles which make motorcycle, car and taxi drivers highly vulnerable to automation (see appendix 2 table A.3).

3.2 Deeper sector-based understanding and internal assessments will enable enterprises to benefit from automation



Despite its accompanying challenges, technology can be a powerful catalyst for growth and productivity gains in the region. One study suggests that deploying disruptive technologies could have a positive macroeconomic impact, increasing ASEAN's GDP by 4–12 per cent by 2030.[28] Because certain ASEAN manufacturing sectors – garments, computers and electronics – will increasingly engage in the use of technology and automation, the economic benefits could be reaped to a larger extent.

> "Globally, robotic usage is concentrated in three major industry groupings – vehicles and transportation equipment, electronics and electrical equipment, and machinery.
>
> Interestingly these are also the same industries that historically had been very susceptible to production fragmentation via global value chains given the complexity of products and processes involved."
>
> Source: Citi Global Perspectives & Solutions: *Technology at Work v2.0: The future is not what it used to be* (2016), p. 25.

As such, the changing landscape of technology-prone sectors challenges the status quo for enterprises in terms of the way they function and their employment needs. To remain competitive, ASEAN enterprises need to position themselves as adopters of enabling technologies and consider a more rigorous assesment of their workforce development strategy.[29] In doing so, the following six questions could be considered:

- What are major technological trends and projections in the sector?
- What is the speed of these technologies' application?
- What are the main factors that influence these technologies' implementation? (wages, productivity, quality, government incentives, and reshoring initiatives, among others)?
- If faced with skills shortage, can technology play a role in addressing the shortage?
- How will enterprise skill needs change when these technologies are adopted?
- What new skills will be required and which will become less relevant?

> "Industries that see faster technological change require more frequent reviews and updates to maintain relevancy to changing labour market demands."
>
> Source: Asian Development Bank, op. cit. p. 49.

28 J. Woetzel et al., op. cit.

29 World Bank, op. cit.

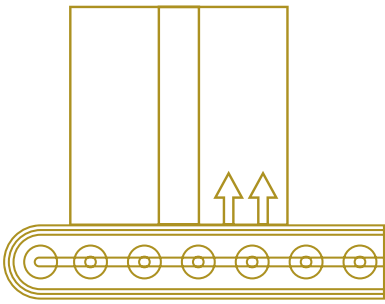
3.3 Government and education and training providers need to actively anticipate for automation impacts

Because automation will most likely impact manufacturing sectors, ASEAN governments and stakeholders must conduct deeper investigations and prudently plan ahead, especially countries that are heavily dependent on one or two labour-intensive subsectors. Governments may need to extensively revamp their economic structures to sustain development and prevent mass disruption. As such, policy-makers will need to carefully think about automation trajectories and take appropriate steps to diversify the country's economy.

For instance, if more than 1 million workers employed in the Philippines BPO sector suddenly become displaced as a result of automation, is the country ready to respond?[30] If automation is rapidly applied to garment and footwear factories in Cambodia, where the sector accounts for around four-fifths of merchandise exports and about three in four salaried jobs in manufacturing, what will happen to half a million sewing machine operators?[31]

Automation and robotic processes are expanding in the BPO sector, replacing routine tasks with modern algorithms to enhance the productivity of back-office work. This trend could undermine the easy opportunities previously available in the sector where basic language and literacy were sufficient skills for a majority of workers.

Source: A.T. Kearney: On the eve of disruption: A new business model threatens established concepts of offshoring and expands the market (2016).



ASEAN governments will need to work with enterprises, workers and educators to respond to automation impacts and conduct reviews guided by the following five questions:

- Which skill levels will be most impacted by job losses in key sectors?
- Is there a re-training programme available for displaced workers?
- In light of emerging technological developments, which core skills (and new skills) will be in most demand by predominant sectors?
- Are education and training providers offering forward-looking training according to the changing enterprise skill needs?
- Is the government and educational ministries placing mechanisms in place to raise the level and quality of education?

These questions should be deployed on a sector-by-sector basis to gain a complete purview of how ASEAN countries can climb up the value-added ladder, strategically utilizing technology to drive productivity and growth.

30 BPO employment estimate based on: Oxford Business Group: The Report: *The Philippines 2015* (London, 2015), citing Central Bank data, www.oxfordbusinessgroup.com/overview/philippines-bpo-sector-creates-jobs-and-drawing-wealth-and-investment [accessed 17 Mar. 2016].

31 Export and employment estimates based on: Huynh, op. cit.; ILO: *Growth continues for Cambodia's garment and footwear sector*, Cambodia Garment and Footwear Sector Bulletin, Issue 1 (Bangkok, 2015).

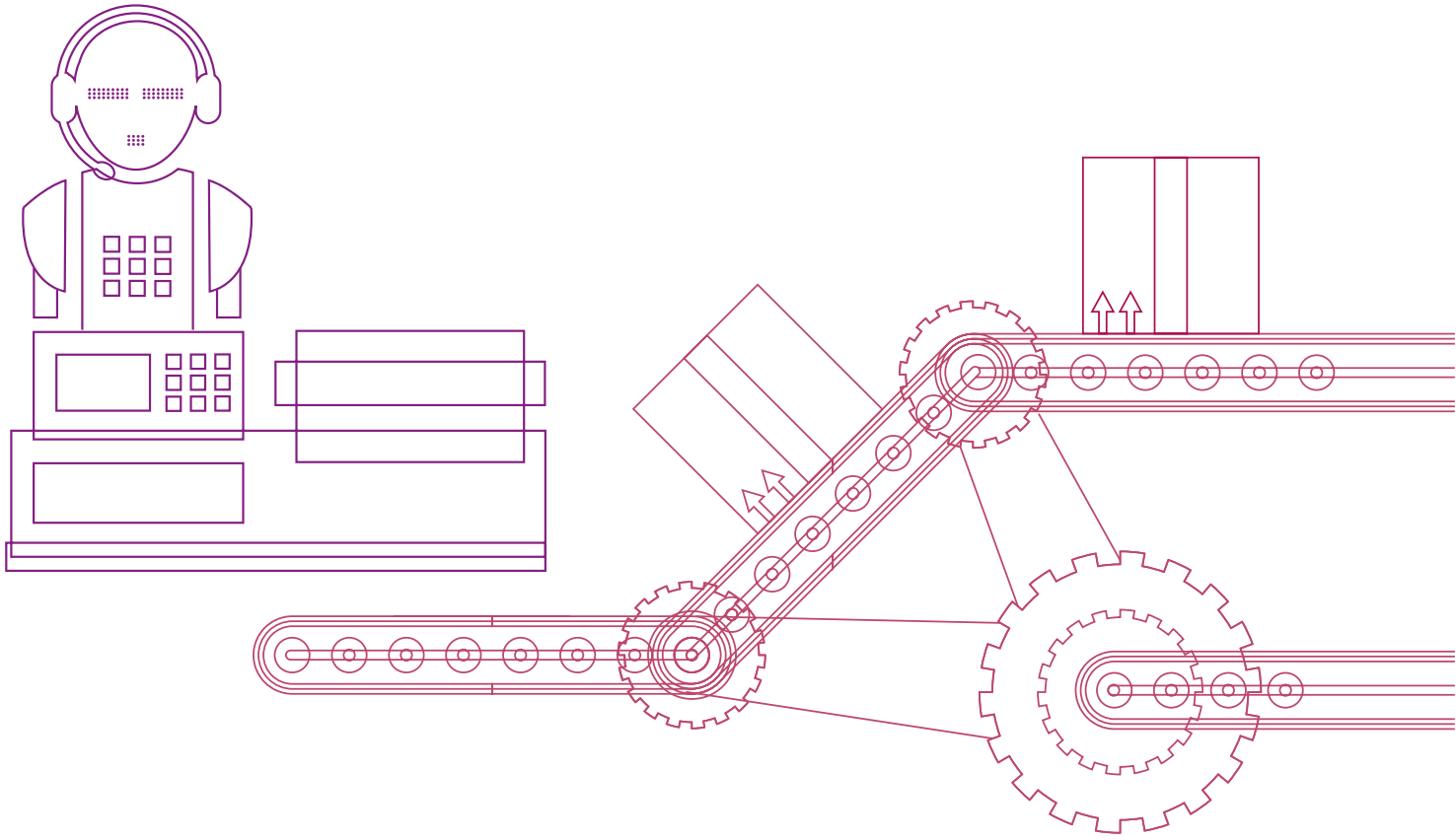
"On average, by 2020, more than a third of the desired core skill sets of most occupations will be comprised of skills that are not yet considered crucial to a job today."

Source: World Economic Forum: The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution (2016), p. 20.

3.4 Looking ahead

One survey shows that 40 per cent of young people around the world are concerned about their jobs being automated in the next decade.[32] Young people's acute awareness of disruptive forces suggests that future workers will seek new and more relevant education and training to meet changing occupational demands.

ASEAN governments, enterprises and stakeholders must look ahead and position themselves strategically to respond to the future workforce's concerns and expectations. Stronger policy commitments and accelerated coordination efforts are especially needed to foster greater cognitive, creative and social intelligence skills within the five ASEAN countries examined in this paper, as 56 per cent of current workers face a high risk of automation. This would enable technological advancement to help sustain and not disrupt the region's growth and dynamism.



32 Infosys: *Amplifying human potential: Education and skills for the Fourth Industrial Revolution* (Bangalore, 2016), p. 23.

APPENDIX 1

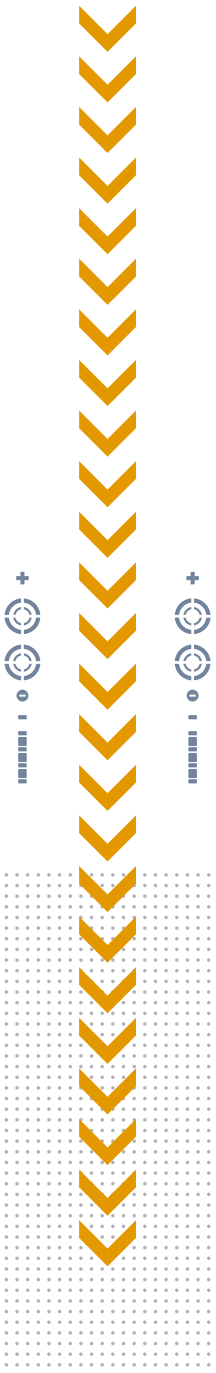
Applying the Frey and Osborne methodology to ASEAN labour force surveys

The analysis calculating the automation risks for jobs in ASEAN uses official national labour force survey data for five countries: Cambodia (2012), Indonesia (August 2010), the Philippines (October 2013), Thailand (quarter 3, 2013) and Viet Nam (2013). The surveys are all nationally representative household surveys based on a rigorous sampling methodology and are carried out by the respective national statistical agencies. Therefore, they provide a robust statistical basis for undertaking the study. Unless specified otherwise, all summary statistics, regression results and quantitative findings on automation risks presented in this paper apply the survey sampling weights.

Each dataset includes a variable that captures both the four-digit occupation code and the occupation title. This is the prerequisite for mapping the national occupational classifications to the corresponding International Standard Classification of Occupations (ISCO) and subsequently to the United States Standard Occupational Classification (SOC) System employed in the original Frey and Osborne study. In order to consistently replicate the same methodology by Frey and Osborne for all the countries under analysis, datasets with less detailed occupation codes at the two-digit or three-digit levels were excluded. As a result, more recent survey data from 2011–2015 for Indonesia were available but not used. Likewise, the Lao People's Democratic Republic Labour Force Survey (2010) was excluded because of the lack of occupation titles needed to map the national occupational classification to ISCO. Labour force survey microdata for the remaining four ASEAN countries (Brunei Darussalam, Malaysia, Myanmar and Singapore) were not available or accessible.[33]

Each of the five datasets used also includes socio-demographic variables that identify sex, age, marital status, urban-rural residency, province or region and educational attainment. They also contain variables for status of employment, based on the International Classification by Status in Employment (ICSE), and economic sector, according to the International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4.[34] In three of the datasets – Cambodia, Indonesia and Viet Nam – a job experience variable is captured and included in the summary statistics and regression analysis. This variable indicates the length of time the employee has worked in that job for that employer. Collectively, these variables are incorporated into a logistic regression model to quantify the relative probability ratios of being employed in an occupation at high risk of automation.

Assessing the automation risks for the five ASEAN countries involved multiple steps required to replicate as closely as possible the same approach used by Frey and Osborne, while taking into consideration differences in occupational categories among the SOC, ISCO and national classifications. The process involved the following procedures:



33 One study has found that around one third of total employment in Singapore is at high risk of automation. Likewise, applying the Frey and Osborne approach to other survey sources, another study estimates that around two-thirds of total employment in Malaysia faces a high risk of automation. See: Centre for Strategic Futures, Prime Minister's Office, Singapore, op. cit.; World Bank, op. cit.

34 The Indonesia dataset employs the ISIC rev. 3 classification.

1) The original list of SOC codes and titles were extracted, along with their respective computed probability of automation from the original Frey and Osborne study.

2) Using the United States Bureau of Labor Statistics (BLS) crosswalk file, SOC and ISCO-08 occupations were matched according to their code.[35]

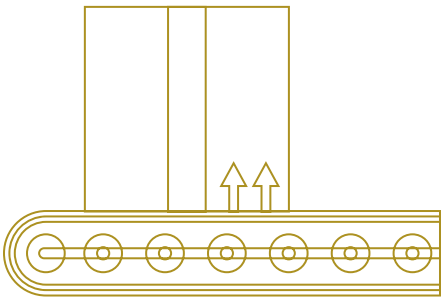
3) This resulted in 31 non-military occupations under the ISCO-08 classification without a direct match to the original SOC list with automation risk estimates from Frey and Osborne. For these limited number of occupations, a value is estimated based on the following sub-procedures:

   a. Occupations were first matched based on occupation titles, if possible. For example, Frey and Osborne estimate the automation risk of 0.4 per cent for "Physicians and Surgeons (29-1060)". We therefore apply the same probability to the ISCO-08 occupations "General medical practitioners (2211)" and "Specialist medical practitioner (2212)"

   b. In other cases, estimates required a matching of not only the occupation title but also its corresponding detailed description of tasks and competencies. This process was based on rigorously examining the descriptions of the jobs and tasks listed in their respective occupation manuals.[36] For example, based on the job-specific tasks required, we link "Computer Support Specialists (15-1150)" to "Information and communications technology user support technicians (3512)".

   c. For the remaining occupations that could not be matched by either the occupation title or detailed description of tasks and competencies, the ISCO-08 occupation was linked to the corresponding SOC category for "Other" or "Not elsewhere classified". In cases where that SOC category did not have an existing probability for automation from the orinal study by Frey and Osborne, the simple unweighted average of the automation risks for the related occupations in that same occupational group (at the three-digit level) was applied. For instance, "Drivers of animal-drawn vehicles and machinery (9332) was linked to "Transportation workers, all others (53-6099)". Since the Frey and Osborne study does not provide an automation risk estimate for the occupation code 53-6099, we take the simple unweighted average automation risks of the related occupations under 53-6000 (or codes 53-6011 to 53-6061).

4) Matching each non-military occupation in the ISCO-08 framework with the equivalent occupation codes and titles from the SOC produced a few cases where an ISCO-08 occupation was linked to multiple SOC occupations and thus several automation probability estimates. In these rare cases, the simple unweighted average of all the automation probabilities for that occupation was estimated and used.



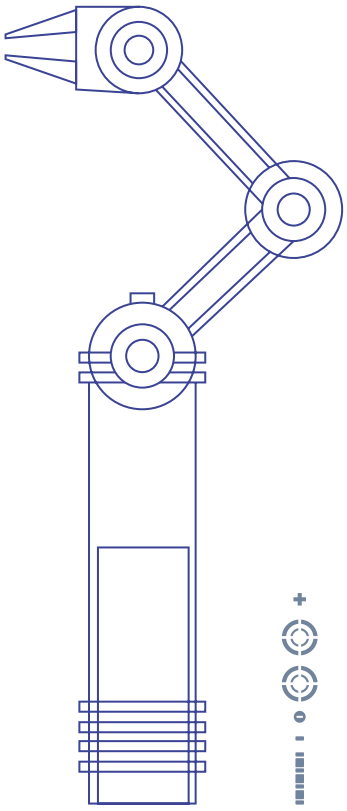
35 The SOC to ISCO-08 crosswalk file by the United States BLS is available at: http://www.bls.gov/soc/soccrosswalks.htm [accessed 14 Dec. 2015].

36 See: ILO, op. cit.; U.S. Bureau of Labor Statistics: *2010 SOC definitions* (Washington, DC, Jan. 2013), http://www.bls.gov/soc/soc_2010_definitions.pdf [accessed 14 Dec. 2015].

5) For Indonesia and the Philippines, the national occupational classifications used in the dataset aligned with ISCO-88 and not ISCO-08. For these two samples, an additional step was needed to map the ISCO-08 occupation codes and titles, along with the automation probability estimates, to the ISCO-88 occupations given that no direct SOC to ISCO-88 crosswalk file was available. This process was done using the standard ISCO-08 to ISCO-88 correspondence tables.[37] This resulted in a few cases where an ISCO-88 occupation was linked to multiple ISCO-08 occupations and therefor multiple automation risk estimates. In these limited instances, the simple unweighted average of all the automation probabilities for that occupation was generated and applied.

6) For Indonesia, the Philippines and Viet Nam an additional step was required because each respective dataset uses a national occupational classification system that includes some limited variances from the ISCO structure. The national occupation codes were matched to the ISCO occupation codes based on a mapping table provided by the respective national statistical office. For any remaining occupations without a direct match, an automation probability estimate was generated by applying the identical methods in steps 3a–3c as outlined above, while referencing the available national occupational classification manuals as needed.

7) Following the same methodology as Frey and Osborne, the final step was to classify each occupation as having low, medium or high risk of automation. These categories correspond respectively to risk probabilities of 0 per cent to 30 per cent, more than 30 per cent but less than or equal to 70 per cent, and more than 70 per cent.



Another step in preparing the survey data for analysis was to derive an hourly wage rate based on total earnings and hours of work. This process allows for assessing the econometric relationship between the risk of automation and earnings. For countries that produce a variable for total earnings in the preceding week of the survey, the hourly rate was estimated by applying the actual hours of work during that reference week. For countries that provide only a monthly wage figure, the hourly wage was calculated by first multiplying the monthly wage figure by 12 (based on 12 months per year) and dividing by 52 (based on 52 weeks per year) and then dividing by the actual hours of work during that reference week.

In addition, variables were harmonized across the five datasets to ensure cross-country comparisons of the logistic regression results. For example, this process involved standardizing the educational attainment variable into three similar categories (primary school graduate or less, secondary school graduate, and post-secondary or tertiary schooling). A similar method was carried out to produce common response categories for the number of years of job experience which were available for Cambodia, Indonesia and Viet Nam. This resulted in four experience classifications: less than one year, one year to less than five years, five years to less than ten years, and ten years or more.

[37] The mapping of the following supervisory positions from the ISCO-08 classifications were excluded due to the extreme downward bias on estimated automation probabilities for non-supervisory occupations in the related categories: mining supervisors (3121), manufacturing supervisors (3122), construction supervisors (3123), office supervisors (3341), cleaning and housekeeping supervisors (5151) and shop supervisors (5222). This step also ensured equivalent automation risk estimates for each occupation across the five country samples regardless of whether the survey data employs the ISCO-08 or ISCO-88 system. The ISCO-08 to ISCO-88 correspondence table is available at: http://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm [accessed 14 Dec. 2015].

APPENDIX 2

Table A.1. Summary statistics, full weighted samples

Worker characteristics	Cambodia N=7 135 373		Indonesia N=107 569 437		Phillippines N=38 421 342		Thailand N=38 951 805		Viet Nam N=52 080 194	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Male	0.52	0.50	0.62	0.49	0.61	0.49	0.55	0.50	0.51	0.50
Female	0.48	0.50	0.38	0.49	0.39	0.49	0.45	0.50	0.49	0.50
Age (years)	34.6	13.85	38.9	13.52	38.0	14.01	41.0	13.23	40.0	13.57
Adult (aged 25+)	0.71	0.45	0.85	0.35	0.81	0.40	0.89	0.32	0.86	0.35
Youth (aged 15-24)	0.29	0.45	0.15	0.35	0.19	0.40	0.11	0.32	0.14	0.35
Urban	0.25	0.43	0.41	0.49	0.48	0.50	n.a.	n.a.	0.30	0.46
Rural	0.75	0.43	0.59	0.49	0.52	0.50	n.a.	n.a.	0.70	0.46
Not married	0.40	0.49	0.26	0.44	0.37	0.48	0.28	0.45	0.23	0.42
Married	0.60	0.49	0.74	0.44	0.63	0.48	0.72	0.45	0.77	0.42
Primary graduate or less	0.89	0.31	0.69	0.46	0.43	0.50	0.67	0.47	0.74	0.44
Secondary graduate	0.06	0.24	0.16	0.36	0.27	0.45	0.15	0.36	0.17	0.38
Post-secondary or tertiary	0.05	0.21	0.16	0.36	0.29	0.46	0.17	0.38	0.09	0.29
Job experience: Less than 1 year	0.27	0.44	0.07	0.25	n.a.	n.a.	n.a.	n.a.	0.06	0.23
Job experience: 1 to less than 5 years	0.40	0.49	0.22	0.42	n.a.	n.a.	n.a.	n.a.	0.30	0.46
Job experience: 5 to less than 10 years	0.13	0.34	0.14	0.35	n.a.	n.a.	n.a.	n.a.	0.23	0.42
Job experience: 10 years or more	0.20	0.40	0.57	0.50	n.a.	n.a.	n.a.	n.a.	0.41	0.49
Agriculture, forestry and fishery	0.34	0.47	0.39	0.49	0.32	0.46	0.42	0.49	0.47	0.50
Mining and quarrying	0.00	0.06	0.01	0.11	0.01	0.08	0.00	0.04	0.01	0.07
Manufacturing	0.18	0.38	0.13	0.33	0.08	0.27	0.14	0.34	0.14	0.35
Electricity, gas, steam and air-conditioners	0.00	0.06	0.00	0.04	0.00	0.05	0.00	0.05	0.00	0.05
Water supply and waste management	0.00	0.06	0.00	0.02	0.00	0.04	0.00	0.05	0.00	0.05
Construction	0.07	0.25	0.05	0.22	0.06	0.24	0.06	0.23	0.06	0.24
Wholesale and retail trade	0.18	0.38	0.17	0.38	0.19	0.39	0.15	0.35	0.13	0.33
Transport and storage	0.05	0.23	0.05	0.21	0.07	0.26	0.02	0.15	0.03	0.17
Hotels and restaurants	0.05	0.21	0.04	0.19	0.04	0.20	0.06	0.23	0.04	0.20
Information and communications	0.00	0.06	0.01	0.08	0.01	0.09	0.00	0.07	0.01	0.07
Financial and insurance activities	0.01	0.08	0.01	0.10	0.01	0.11	0.01	0.10	0.01	0.08
Real estate activities	0.00	0.05	0.00	0.04	0.00	0.06	0.00	0.06	0.00	0.05
Professional, scientific and technical activity	0.00	0.06	0.00	0.06	0.01	0.07	0.01	0.08	0.00	0.07
Administrative and support service activity	0.01	0.11	0.00	0.04	0.03	0.16	0.01	0.10	0.00	0.07
Public administration and defense; compulsory social security	0.03	0.18	0.03	0.16	0.05	0.21	0.04	0.20	0.03	0.17
Education and training	0.02	0.16	0.04	0.21	0.03	0.18	0.03	0.17	0.03	0.18
Human health and social work activities	0.01	0.10	0.01	0.10	0.01	0.11	0.02	0.13	0.01	0.10
Arts, entertainment and recreation	0.01	0.11	0.00	0.07	0.01	0.09	0.01	0.08	0.01	0.07
Other service activities	0.02	0.13	0.03	0.18	0.06	0.23	0.02	0.12	0.01	0.12
Activities of households as employers of domestic workers	0.01	0.08	0.02	0.15	0.01	0.11	0.00	0.07	0.00	0.06
Activities of extraterritorial organizations	0.00	0.06	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01
Employer	0.00	0.06	0.23	0.42	0.03	0.18	0.03	0.16	0.02	0.16
Wage employee	0.46	0.50	0.40	0.49	0.58	0.49	0.41	0.49	0.35	0.48
Own-account worker	0.34	0.47	0.20	0.40	0.28	0.45	0.33	0.47	0.46	0.50
Contributing family worker	0.20	0.40	0.17	0.38	0.11	0.31	0.23	0.42	0.17	0.38
Occupation-based skill: Low	0.18	0.38	0.13	0.33	0.33	0.47	0.09	0.28	0.41	0.49
Occupation-based skill: Medium	0.72	0.45	0.79	0.41	0.44	0.50	0.77	0.42	0.49	0.50
Occupation-based skill: High	0.10	0.30	0.09	0.28	0.24	0.42	0.14	0.35	0.10	0.30

Note: Includes workers aged 15 and above. High skill occupations are defined as ISCO groups 1 (managers), 2 (professionals) and 3 (technicians and associate professionals); medium-skill occupations include ISCO groups 4 (clerks), 5 (service and sales workers), 6 (skilled agricultural and fishery workers), 7 (craft and related trade workers) and 8 (plant and machine operators and assemblers); and low-skill occupations consist of ISCO group 9 (elementary occupations). Automation risk categorized by low probability (less than 30 per cent), medium probability (30 per cent to 70 per cent) and high probability (exceeds 70 per cent). Includes only non-military employment for which a probability of automation could be estimated. Survey sampling weights applied.

Source: Authors' estimates based on Cambodia Labour Force Survey (2012), Indonesia Labour Force Survey (Aug. 2010), Philippines Labour Force Survey (Oct. 2013), Thailand Labour Force Survey (Q3 2013) and Viet Nam Labour Force Survey (2013), applying the Frey and Osborne (2013) methodology at the four-digit occupation level.

Table A.2. Employment by sex and risk of automation (thousand and per cent distribution by risk)

Country and sex	Low	Medium	High	Total	Low	Medium	High	Total
Cambodia	805.4	2 280.4	4 049.5	7 135.4	11.3	32.0	56.8	100.0
Male	451.8	1 380.1	1 904.2	3 736.1	12.1	36.9	51.0	100.0
Female	353.6	900.3	2 145.4	3 399.3	10.4	26.5	63.1	100.0
Indonesia	10 076.8	37 074.7	60 418.0	107 569.4	9.4	34.5	56.2	100.0
Male	5 569.6	24 178.3	37 103.2	66 851.1	8.3	36.2	55.5	100.0
Female	4 507.1	12 896.4	23 314.8	40 718.3	11.1	31.7	57.3	100.0
Philippines	7 042.6	12 580.2	18 798.5	38 421.3	18.3	32.7	48.9	100.0
Male	2 807.2	9 619.6	10 883.8	23 310.6	12.0	41.3	46.7	100.0
Female	4 235.4	2 960.6	7 914.7	15 110.8	28.0	19.6	52.4	100.0
Thailand	5 918.1	15 832.3	17 201.4	38 951.8	15.2	40.6	44.2	100.0
Male	3 134.2	9 545.0	8 588.3	21 267.5	14.7	44.9	40.4	100.0
Female	2 783.9	6 287.3	8 613.0	17 684.3	15.7	35.6	48.7	100.0
Viet Nam	6 120.2	9 278.9	36 681.1	52 080.2	11.8	17.8	70.4	100.0
Male	3 920.0	6 320.5	16 476.2	26 716.8	14.7	23.7	61.7	100.0
Female	2 200.2	2 958.4	20 204.9	25 363.4	8.7	11.7	79.7	100.0
ASEAN-5	29 963.1	77 046.5	137 148.6	244 158.2	12.3	31.6	56.2	100.0
Male	15 882.8	51 043.5	74 955.7	141 882.1	11.2	36.0	52.8	100.0
Female	14 080.2	26 003.0	62 192.8	102 276.1	13.8	25.4	60.8	100.0

Note: Includes workers aged 15 and above. ASEAN-5 represents the aggregate total of Cambodia, Indonesia, Philippines, Thailand and Viet Nam. Automation risk categorized by low probability (less than 30 per cent), medium probability (30 per cent to 70 per cent) and high probability (exceeds 70 per cent). Includes only non-military occupations for which a probability of automation could be estimated. Survey sampling weights applied.
Source: Same as appendix 2 table A.1

Table A.3. Share of employment by one-digit sector and risk category of automation (per cent)

High-risk sector	Cambodia	Indonesia	Philippines	Thailand	Viet Nam	ASEAN-5
Total	**56.8**	**56.2**	**48.9**	**44.2**	**70.4**	**56.2**
A. Agriculture, forestry and fishery	45.9	50.0	59.4	32.9	83.3	56.6
B. Mining and quarrying	43.5	14.2	6.2	37.0	31.7	17.0
C. Manufacturing	75.3	55.7	46.2	65.4	74.4	61.6
D. Electricity, gas, steam and air-conditioners	6.2	51.7	45.7	37.1	50.4	45.3
E. Water supply; sewerage, waste management and remediation activities	77.1	57.0	48.4	36.8	46.5	47.4
F. Construction	88.6	80.8	86.2	70.0	40.6	70.8
G. Wholesale and retail trade; repair of motor vehicles and motorcycles	80.5	91.1	57.5	50.7	84.1	77.5
H. Transport and storage	17.2	23.3	9.5	17.8	17.9	18.2
I. Hotels and restaurants	73.3	77.9	67.8	84.8	93.0	80.7
J. Information and communications	53.7	53.8	35.1	34.2	32.2	43.0
K. Financial and insurance activities	48.2	71.6	61.2	40.3	45.6	59.2
L. Real estate activities	0.0	40.0	15.6	38.6	40.9	32.5
M. Professional, scientific and technical activities	19.2	42.8	32.6	34.1	27.4	35.1
N. Administrative and support service activities	43.7	35.7	48.5	52.2	39.8	47.0
O. Public administration and defense; compulsory social security	32.9	61.5	35.8	29.7	35.4	43.3
P. Education and training	3.6	9.2	8.4	10.0	7.6	8.7
Q. Human health and social work activities	10.8	23.4	16.1	17.8	13.1	18.7
R. Arts, entertainment and recreation	14.8	33.9	29.1	54.4	68.9	42.3
S. Other service activities	15.5	37.0	25.3	38.6	16.9	31.2
T. Activities of households as employers of domestic workers	33.0	25.0	0.2	20.5	9.0	20.3
U. Activities of extraterritorial organizations and bodies	43.4	32.7	19.2	70.0	25.6	42.0
X. Unknown/unclassifiable	n.a.	77.4	n.a.	46.7	49.9	72.2

Medium-risk sector	Cambodia	Indonesia	Philippines	Thailand	Viet Nam	ASEAN-5
Total	**32.0**	**34.5**	**32.7**	**40.6**	**17.8**	**31.6**
A. Agriculture, forestry and fishery	54.0	49.9	40.4	66.8	16.6	43.3
B. Mining and quarrying	53.5	83.4	78.6	50.8	57.6	77.5
C. Manufacturing	16.0	34.1	30.2	20.7	17.6	26.8
D. Electricity, gas, steam and air-conditioners	65.6	38.1	34.3	17.3	15.4	29.0
E. Water supply; sewerage, waste management and remediation activities	22.0	37.7	38.6	52.0	43.7	43.1
F. Construction	1.0	8.1	3.6	5.9	4.2	5.8
G. Wholesale and retail trade; repair of motor vehicles and motorcycles	9.6	5.4	5.7	18.1	12.2	8.6
H. Transport and storage	81.5	73.0	89.9	77.0	77.0	78.6
I. Hotels and restaurants	17.3	18.5	11.3	5.7	4.9	11.8
J. Information and communications	36.9	30.2	29.5	24.0	21.1	27.7
K. Financial and insurance activities	30.2	17.9	16.9	38.8	36.7	24.6
L. Real estate activities	22.4	35.0	43.6	39.6	40.6	39.0
M. Professional, scientific and technical activities	17.7	28.7	25.8	20.6	23.3	24.9
N. Administrative and support service activities	46.2	29.3	42.1	35.3	38.3	39.5
O. Public administration and defense; compulsory social security	10.6	12.6	23.2	23.5	13.7	17.4
P. Education and training	0.9	2.5	2.6	14.0	5.6	4.6
Q. Human health and social work activities	1.9	9.5	13.4	24.6	15.5	14.6
R. Arts, entertainment and recreation	42.7	19.4	42.3	21.3	14.5	25.4
S. Other service activities	71.5	47.4	65.9	52.3	71.2	56.2
T. Activities of households as employers of domestic workers	65.9	68.7	99.7	76.7	80.1	74.4
U. Activities of extraterritorial organizations and bodies	21.3	16.7	15.3	26.6	36.0	22.8
X. Unknown/unclassifiable	n.a.	18.6	n.a.	28.2	28.1	20.2

Low-risk sector	Cambodia	Indonesia	Philippines	Thailand	Viet Nam	ASEAN-5
Total	**11.3**	**9.4**	**18.3**	**15.2**	**11.8**	**12.3**
A. Agriculture, forestry and fishery	0.1	0.1	0.2	0.3	0.1	0.2
B. Mining and quarrying	3.0	2.4	15.1	12.1	10.6	5.5
C. Manufacturing	8.7	10.1	23.6	13.9	8.0	11.6
D. Electricity, gas, steam and air-conditioners	28.2	10.2	20.0	45.6	34.2	25.7
E. Water supply; sewerage, waste management and remediation activities	0.9	5.3	13.0	11.3	9.8	9.5
F. Construction	10.4	11.1	10.1	24.1	55.2	23.4
G. Wholesale and retail trade; repair of motor vehicles and motorcycles	9.9	3.5	36.8	31.1	3.6	13.9
H. Transport and storage	1.3	3.7	0.6	5.2	5.1	3.1
I. Hotels and restaurants	9.4	3.6	21.0	9.6	2.1	7.5
J. Information and communications	9.3	16.0	35.4	41.8	46.8	29.4
K. Financial and insurance activities	21.6	10.5	21.9	20.9	17.7	16.2
L. Real estate activities	77.6	25.0	40.9	21.8	18.5	28.5
M. Professional, scientific and technical activities	63.1	28.6	41.6	45.2	49.4	40.0
N. Administrative and support service activities	10.1	35.0	9.4	12.4	21.9	13.5
O. Public administration and defense; compulsory social security	56.5	26.0	41.0	46.8	50.8	39.3
P. Education and training	95.5	88.3	89.0	76.0	86.8	86.7
Q. Human health and social work activities	87.3	67.1	70.5	57.6	71.3	66.7
R. Arts, entertainment and recreation	42.5	46.7	28.6	24.3	16.6	32.4
S. Other service activities	13.0	15.7	8.8	9.1	11.8	12.6
T. Activities of households as employers of domestic workers	1.1	6.3	0.1	2.8	10.9	5.3
U. Activities of extraterritorial organizations and bodies	35.3	50.6	65.5	3.5	38.4	35.1
X. Unknown/unclassifiable	n.a.	4.0	n.a.	25.0	22.0	7.6

Source: Same as appendix 2, table A.1.

Table A.4. Leading occupations by employment in categories of low and high risk of automation

Low-risk occupations	Employment (000)	Risk of automation (%)	High-risk occupations	Employment (000)	Risk of automation (%)
Cambodia					
1. Shop keepers	144.5	16.0	1. Stall and market salespersons	999.0	94.0
2. Handicraft workers in wood and basketry	78.7	3.5	2. Crop farm labourers	616.2	87.0
3. Primary school teachers	78.1	8.7	3. Sewing machine operators	446.9	89.0
4. Secondary education teachers	51.5	0.8	4. Livestock and dairy producers	263.2	76.0
5. Police officers	44.4	22.4	5. Building construction labourers	242.7	80.0
6. Traditional chiefs and heads of village	39.3	1.5	6. Bakers, pastry-cooks and confectionery makers	92.4	89.0
7. Construction supervisors	27.5	17.0	7. Street food salespersons	89.8	90.0
8. Senior government officials	23.1	5.9	8. Bricklayers and related workers	78.6	82.0
9. Manufacturing supervisors	23.0	1.6	9. Forestry and related workers	69.6	79.2
10. Generalist medical practitioners	22.9	0.4	10. Tailors, dressmakers, furriers and hatters	68.0	84.0
Indonesia					
1. Primary education teaching professionals	1 869.9	8.7	1. Stall and market salespersons	14 323.8	93.5
2. Other personal services workers n.e.c.*	1 130.8	27.9	2. Gardeners, horticultural and nursery growers	9 105.1	81.0
3. Junior secondary education teaching professionals	690.6	7.1	3. Market-oriented crop and animal producers	5 943.1	76.0
4. Basketry weavers and brush makers	670.7	3.5	4. Subsistence agricultural and fishery workers	2 558.3	85.3
5. Builders, traditional materials	489.0	7.1	5. Building construction labourers	2 133.1	80.0
6. Senior secondary education teaching professionals	485.7	7.1	6. Street food vendors	1 891.7	90.0
7. Pre-primary education teaching professionals	448.3	7.9	7. Shop salespersons and demonstrators	1 771.3	75.8
8. Other teaching professionals n.e.c.	397.4	8.9	8. Other office clerks	1 652.4	93.3
9. General managers n.e.c.	253.7	9.0	9. Bricklayers and stonemasons	1 476.2	84.0
10. General managers in wholesale and retail trade	249.4	16.0	10. Tailors, dressmakers and hatters	1 119.3	84.0
Philippines					
1. General managers in wholesale and retail trade	2 424.4	16.0	1. Farmhands and labourers	5 888.9	89.0
2. General elementary education teachers	539.5	8.7	2. Shop salespersons and demonstrators	2 154.4	75.8
3. General managers in manufacturing	471.3	14.0	3. Market and sidewalk stall vendors	897.5	92.0
4. General managers of business services	311.9	13.4	4. Building construction labourers	869.2	80.0
5. General managers of restaurants and hotels	278.3	4.3	5. Fishery labourers and helpers	579.5	83.0
6. Traditional chiefs and heads of villages	243.0	1.5	6. Waiters, waitresses and bartenders	574.0	83.5
7. General secondary education teachers	235.7	7.1	7. Carpenters and joiners	525.2	72.0
8. Professional nurses	191.1	3.7	8. Hand launderers and pressers	485.3	81.0
9. Police officers	140.4	22.4	9. Helpers and cleaners in offices and hotels	463.0	71.2
10. Building and related electricians	135.6	15.0	10. Receptionists and information clerks	463.0	78.0
Thailand					
1. Shopkeepers	1 165.6	16.0	1. Subsistence crop farmers	3 306.3	87.0
2. Retail and wholesale trade managers	440.0	16.0	2. Shop sales assistants	991.5	95.0
3. Primary school teachers	385.4	8.7	3. Stall and market salespersons	891.3	94.0
4. Construction managers	227.7	7.1	4. Crop farm labourers	786.3	87.0
5. Secondary education teachers	207.0	0.8	5. Livestock and dairy producers	671.4	76.0
6. Building and related electricians	195.5	15.0	6. Food service counter attendants	623.8	93.0
7. Traditional chiefs and heads of villages	185.2	1.5	7. Cooks	605.5	73.2
8. Handicraft workers in wood and basketry	172.1	3.5	8. Building construction labourers	581.6	80.0
9. Restaurant managers	152.9	8.3	9. General office clerks	421.7	97.0
10. Finance managers	145.6	6.9	10. Accounting associate professionals	403.3	98.0
Viet Nam					
1. House builders	1 599.2	7.1	1. Crop farm labourers	12 770.4	87.0
2. Secondary school education teachers	338.0	0.8	2. Stall and market salespersons	3 892.6	94.0
3. Primary school teachers	249.7	8.7	3. Livestock farm labourers	2 558.0	87.0
4. Primary school teachers, medium-sized schools	207.0	8.7	4. Shop sales assistants	2 120.7	95.0
5. Handicraft workers in wood and basketry	195.5	3.5	5. Garden and horticultural labourers	1 005.6	95.0
6. Early childhood teachers	165.4	7.9	6. Subsistence crop farmers	933.9	87.0
7. High School education teachers	162.3	0.8	7. Building construction labourers	911.1	80.0
8. Handicraft workers n.e.c.	161.2	3.5	8. Fishery and aquaculture labourers	842.6	83.0
9. Nursing associate professionals	158.0	5.8	9. Sewing machine operators	769.2	89.0
10. Management and organization analysts	153.5	7.1	10. Livestock and dairy producers	693.6	76.0

Note: Low and high risks defined respectively as occupations with an automation probability of less than 30 per cent and greater than 70 per cent. Due to different survey sample sizes, the statistical significance of employment estimates vary and therefore should be interpreted for illustrative purposes only.

* n.e.c. = not elsewhere classified.

Source: Same as appendix 2, table A.1.

Table A.5. Logistic regression results with employment at high risk of automation as the dependent variable

Variable	(1) Cambodia	(2) Indonesia	(3) Philippines	(4) Thailand	(5) Viet Nam
Female sex dummy	1.558	1.16	2.382	1.521	2.32
	(0.003)**	(0.001)**	(0.003)**	(0.001)**	(0.002)**
Secondary education dummy	0.821	0.938	0.782	0.75	0.913
	(0.004)**	(0.001)**	(0.001)**	(0.001)**	(0.001)**
Post-secondary or tertiary education dummy	0.825	0.656	0.537	0.53	0.327
	(0.005)**	(0.001)**	(0.001)**	(0.001)**	(0.001)**
1-5 years of experience dummy	1.023	1.027			0.891
	(0.003)**	(0.001)**			(0.002)**
5-10 years of experience dummy	0.77	1.115			0.847
	(0.003)**	(0.001)**			(0.002)**
10+ years of experience dummy	0.722	1.158			0.783
	(0.002)**	(0.001)**			(0.001)**
Age	0.995	0.997	0.991	0.963	0.962
	(0.001)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Age^2	0.998	0.995	0.997	1.034	1.045
	(0.001)*	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Youth dummy	1.106	1.041	1.175	0.859	1.129
	(0.005)**	(0.001)**	(0.002)**	(0.002)**	(0.002)**
Married dummy	0.983	0.991	0.936	0.888	0.95
	(0.002)**	(0.001)**	(0.001)**	(0.001)**	(0.001)**
Rural residency dummy	0.512	1.052	0.811		0.966
	(0.002)**	(0.001)**	(0.001)**		(0.001)**
Wage employee dummy	6.283	2.153	145.869	8.012	1.279
	(0.085)**	(0.001)**	(0.685)**	(0.024)**	(0.003)**
Own-account worker dummy	1.242	1.844	5.308	4.613	1.73
	(0.017)**	(0.001)**	(0.025)**	(0.014)**	(0.004)**
Contributing family worker dummy	0.754	0.834	446.054	4.576	3.726
	(0.010)**	(0.001)**	(2.341)**	(0.014)**	(0.010)**
Mining and quarrying dummy	0.333	0.103	0.009	1.098	0.158
	(0.004)**	(0.000)**	(0.000)**	(0.010)**	(0.001)**
Manufacturing dummy	1.764	0.961	0.11	3.476	0.845
	(0.005)**	(0.001)**	(0.000)**	(0.005)**	(0.001)**
Electricity, gas, steam dummy	0.027	0.796	0.129	1.147	0.547
	(0.001)**	(0.004)**	(0.001)**	(0.008)**	(0.003)**
Water supply and waste management dummy	2.714	0.96	0.135	1.082	0.292
	(0.046)**	(0.008)**	(0.001)**	(0.007)**	(0.002)**
Construction dummy	2.776	2.854	1.003	5.509	0.24
	(0.015)**	(0.003)**	-0.002	(0.010)**	(0.000)**
Wholesale and retail trade dummy	5.528	9.895	0.755	2.447	1.473
	(0.017)**	(0.010)**	(0.001)**	(0.003)**	(0.002)**
Transport and storage dummy	0.1	0.22	0.025	0.511	0.07
	(0.001)**	(0.000)**	(0.000)**	(0.002)**	(0.000)**
Hotels and restaurants dummy	2.155	3.332	0.685	15.037	3.438
	(0.010)**	(0.004)**	(0.002)**	(0.032)**	(0.010)**
Information and communications dummy	0.389	1.06	0.073	1.319	0.24
	(0.006)**	(0.003)**	(0.000)**	(0.007)**	(0.001)**
Financial and insurance dummy	0.354	1.912	0.199	1.539	0.469
	(0.004)**	(0.005)**	(0.001)**	(0.005)**	(0.002)**
Real estate dummy		0.531	0.028	1.478	0.231
		(0.003)**	(0.000)**	(0.009)**	(0.001)**
Professional, scientific and technical dummy	0.146	0.619	0.072	1.499	0.195
	(0.003)**	(0.002)**	(0.000)**	(0.007)**	(0.001)**
Administrative and support service dummy	0.203	0.479	0.117	2.382	0.23
	(0.002)**	(0.003)**	(0.000)**	(0.008)**	(0.001)**
Public administration and defense dummy	0.159	1.172	0.069	0.774	0.28
	(0.001)**	(0.002)**	(0.000)**	(0.002)**	(0.001)**
Education and training dummy	0.01	0.072	0.009	0.193	0.031
	(0.000)**	(0.000)**	(0.000)**	(0.001)**	(0.000)**
Human health and social work dummy	0.034	0.227	0.019	0.325	0.041
	(0.000)**	(0.001)**	(0.000)**	(0.001)**	(0.000)**
Arts, entertainment and recreation dummy	0.048	0.383	0.048	2.589	0.758
	(0.001)**	(0.001)**	(0.000)**	(0.011)**	(0.003)**
Other service activities dummy	0.096	0.452	0.028	1.285	0.041
	(0.001)**	(0.001)**	(0.000)**	(0.004)**	(0.000)**
Household employers of domestic workers dummy	0.091	0.19	0	0.272	0.016
	(0.001)**	(0.000)**	(0.000)**	(0.002)**	(0.000)**
Extraterritorial organizations dummy	0.185	0.559	0.029	3.784	0.18
	(0.003)**	(0.033)**	(0.001)**	(0.135)**	(0.007)**
N	22 820	530 832	82 703	129 524	429 442

Note: Standard errors in parentheses; * significant at five per cent; ** significant at one per cent; N = number of unweighted observations.
Results of logistic regressions which exhibit the probability ratios of employment (ages 15 and above) in an occupation at high risk of automation. Base cases for dummy variables include: (1) Sex: male; (2) Education: completed primary education or less; (3) Experience: less than 1 year of job experience; (4) Youth (aged 15-24) status: adults aged 25 and above; (5) Marital status: unmarried; (6) Residency: urban residence; (7) Employment status: employer; (8) Economic sector: agriculture, forestry and fishery. For brevity, the regression coefficients for province/region dummy variables are not presented. A variable for job experience is included in only the Cambodia, Indonesia and Viet Nam datasets. High risk includes non-military occupations with a probability of automation that exceeds 70 per cent. Survey sampling weights applied.
Source: Same as appendix 2 table A.1.

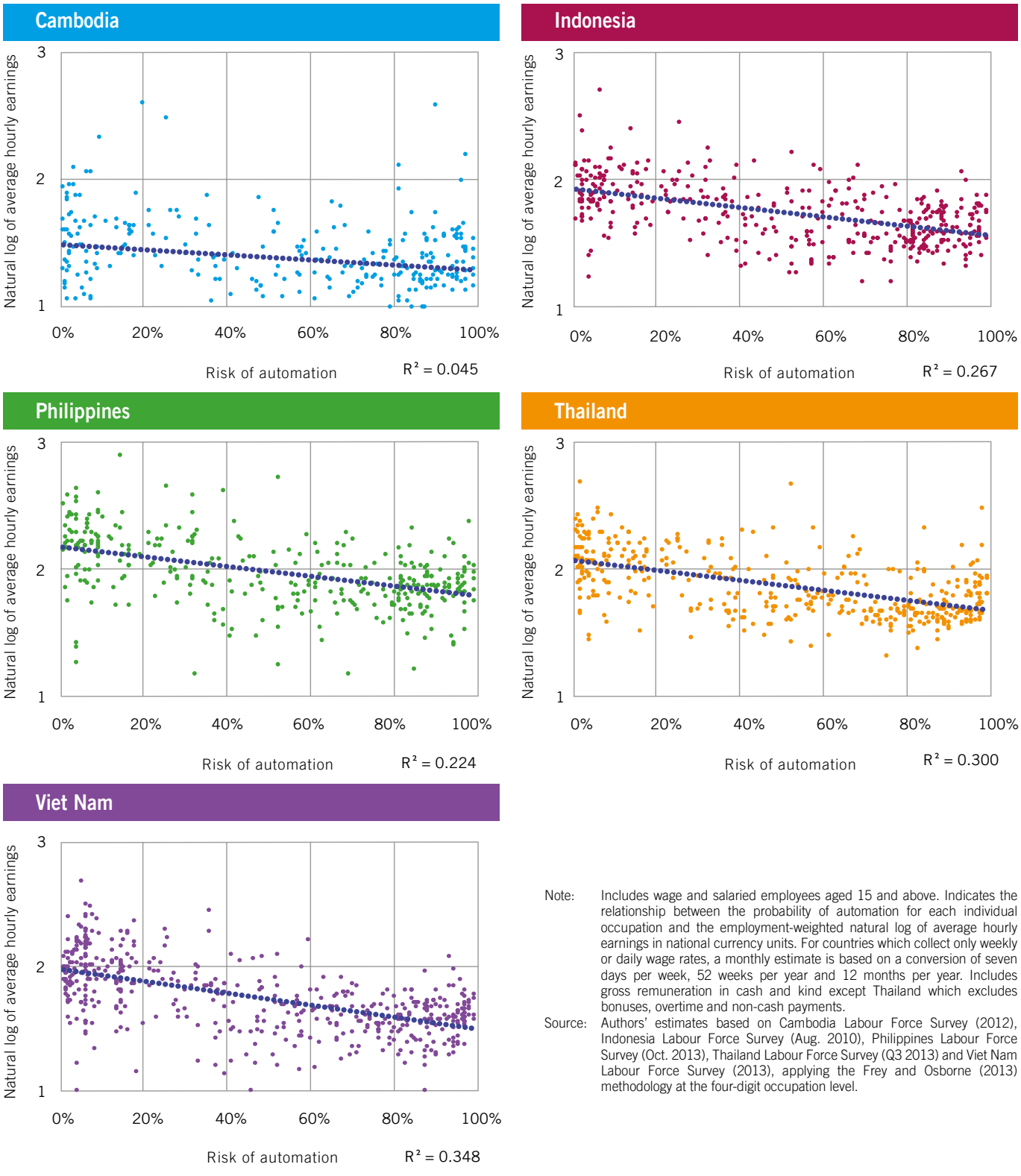
APPENDIX 3

Figure A.1. Relationship between probability of automation and average educational attainment

Note: Includes workers aged 15 and above. Indicates the relationship between the probability of automation for each individual occupation and the employment-weighted average of educational attainment. Educational attainment levels correspond to: (1) primary school graduate or lower, (2) upper secondary school graduate, (3) post-secondary and tertiary studies.

Source: Authors' estimates based on Cambodia Labour Force Survey (2012), Indonesia Labour Force Survey (Aug. 2010), Philippines Labour Force Survey (Oct. 2013), Thailand Labour Force Survey (Q3 2013) and Viet Nam Labour Force Survey (2013), applying the Frey and Osborne (2013) methodology at the four-digit occupation level.

Figure A.2. Relationship between probability of automation and average hourly earnings



Note: Includes wage and salaried employees aged 15 and above. Indicates the relationship between the probability of automation for each individual occupation and the employment-weighted natural log of average hourly earnings in national currency units. For countries which collect only weekly or daily wage rates, a monthly estimate is based on a conversion of seven days per week, 52 weeks per year and 12 months per year. Includes gross remuneration in cash and kind except Thailand which excludes bonuses, overtime and non-cash payments.

Source: Authors' estimates based on Cambodia Labour Force Survey (2012), Indonesia Labour Force Survey (Aug. 2010), Philippines Labour Force Survey (Oct. 2013), Thailand Labour Force Survey (Q3 2013) and Viet Nam Labour Force Survey (2013), applying the Frey and Osborne (2013) methodology at the four-digit occupation level.

ASEAN in transformation: The future of jobs at risk of automation

This paper seeks to understand the implications of computerized technology for five ASEAN economies – Cambodia, Indonesia, the Philippines, Thailand and Viet Nam – by assessing the types of occupations in the region that have a high probability of being automated. The ASEAN-5 results show that approximately 56 per cent of all employment is at high risk of automation. Certain industries with high capacity for automation include hotels and restaurants, wholesale and retail trade, construction and manufacturing. Industries with low automation risk are education and training as well as human health and social work. Overall, the paper aims to provide businesses, workers, jobseekers and policy-makers valuable insight into how different segments of ASEAN's workforce could be affected by rapid advances in engineering and to help spur actions addressing the need for innovative skills and workforce development.

ACT/EMP
The Bureau for Employers' Activities

ISBN 978-92-2-130965-9

Bureau for Employers' Activities (ACT/EMP)
International Labour Office
Route des Morillons 4
CH-1211 Geneva 22
Switzerland
Email: actemp@ilo.org