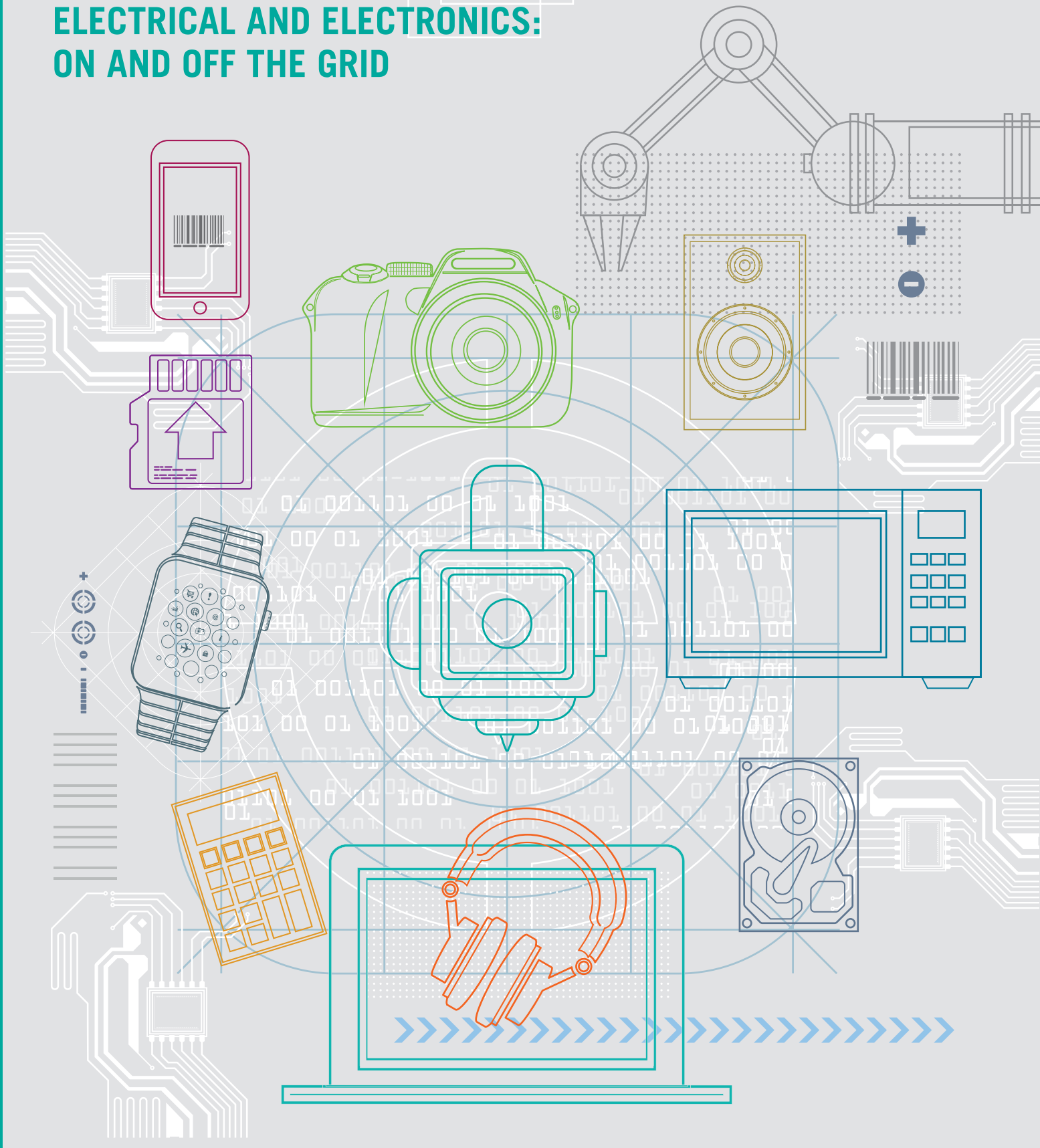
# ASEAN IN TRANSFORMATION

## ELECTRICAL AND ELECTRONICS: ON AND OFF THE GRID



International Labour Organization

# ASEAN IN TRANSFORMATION

## ELECTRICAL AND ELECTRONICS: ON AND OFF THE GRID

July 2016

**Gary Rynhart, Jae-Hee Chang and Phu Huynh**

Bureau for Employers' Activities (ACT/EMP), Working Paper No.13

International Labour Office

First published (2016)

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ASEAN in transformation : electrical and electronics: on and off the grid / Gary Rynhart, Jae-Hee Chang, Phu Huynh ; International Labour Office, Bureau for Employers' Activities (ACT/EMP). - Geneva: ILO, 2016 (Bureau for Employers' Activities (ACT/EMP) working paper ; No. 13)

ISBN: 9789221311836 (web pdf)

International Labour Office Bureau for Employers' Activities.

future of work / technological change / electrical industry / electronics industry / ASEAN countries

13.01.1
ILO Cataloguing in Publication Data

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Layout and design by QUO, Bangkok

# PREFACE

This paper, *ASEAN in Transformation: Electrical and electronics – On and off the grid*, examines how technology is transforming the electrical and electronics (E&E) sector in the Association of Southeast Asian Nations (ASEAN).

The E&E sector is one of the region's most prominent sectors and a mainstay of economic growth, especially as the region moves up the value ladder in manufacturing and shifts away from low-cost production. ASEAN's diverse E&E activities, from high-tech design research and innovation to low-skilled assembling and packaging, make the region an attractive destination for manufacturing.

The E&E industry is poised for growth due to technology trends such as the Internet of Things (IoT) but also likely to be significantly impacted by other disruptors such as additive manufacturing. ASEAN's E&E sector represents a key opportunity for the region as it becomes increasingly connected both directly and indirectly to every economic industry. However, as technology adoption increases and the skills needs of the sector shift, it becomes imperative to improve the skills pipeline to ensure that the industry in ASEAN can take advantage of the potential for growth.

The findings from this paper are based on an in-depth sector study with more than 70 interviews and detailed case studies conducted across ASEAN mainly in Indonesia, Malaysia, the Philippines, and Viet Nam, supplemented by a separate study that examines technology trends and the relationship between China and ASEAN for the E&E sector.

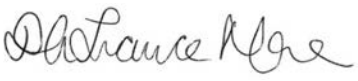
The paper forms part of the ILO Bureau for Employers' Activities (ACT/EMP) research project on the future of work and how technology is transforming jobs and enterprises in the ASEAN region. Drawing from numerous interviews and case studies, the team examined current technological trends in the ASEAN region and how they impact on enterprises and workers within five major labour-intensive and/or growth manufacturing and services sectors: automotive and auto parts; electrical and electronics; textiles, clothing and footwear; business process outsourcing; and retail.

The wider research effort has culminated into a collection of separate papers, of which this paper forms a part, 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 key findings from this paper, and the abovementioned, are synthesized in a master document entitled, *ASEAN in transformation: How technology is changing jobs and enterprises*.

We hope this paper and its associated research provide enterprises, workers and their representative organizations, governments 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 effort 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

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# ACKNOWLEDGEMENTS

As part of the broader research project, this paper owes credit and thanks to all those who participated in this process for helping to shape the overall understanding of the topic.

Richard Brubaker, China Europe International Business School and William Morris, Collective Responsibility, provided the China-ASEAN trends and undertook extensive research that contributed to this paper.

In addition, research by Rajah Rasiah, University of Malaya, and Ngoc Pham Quang were used as inputs to this paper.

Thank you to Simon Fried, Nano Dimension, for helpful comments on the early draft.

## ABOUT THE RESEARCH TEAM

The ILO research team consisted of Gary Rynhart, Senior Employers' Specialist, ILO Decent Work Technical Support Team for East and South-East Asia; Jae-Hee Chang, Employers' Specialist, ILO-ACT/EMP; and Phu Huynh, Labour Economist, ILO Regional Office for Asia and the Pacific. They were assisted by Laura Greene and Linda Vega Orozco.

## ABOUT THE BUREAU FOR EMPLOYERS' ACTIVITIES

The Bureau for Employers' Activities (ACT/EMP) is the specialized unit within the International Labour Office that maintains direct and close relationships with employers' organizations. Employers' organizations advance the collective interests of employers at country and regional levels. ACT/EMP assists employers' organizations with becoming strong representative organizations that help to shape conducive business environments.

# ABBREVIATIONS

| | |
|---|---|
| **3C** | computers, consumer and communication electronics |
| **ASEAN** | Association of Southeast Asian Nations |
| **BCG** | Boston Consulting Group |
| E**&**E | electrical and electronics |
| **FDI** | foreign direct investment |
| **IC** | integrated circuits |
| **IoT** | Internet of Things |
| **ISCO** | International Standard Classification of Occupations |
| **ISIC** | The International Standard Industrial Classification of All Economic Activities |
| **LED** | light-emitting diode |
| **MNE** | multinational enterprise |
| **PCB** | printed circuit boards |
| **R&D** | research and development |
| **ROI** | return on investment |
| **SITC** | Standard International Trade Classification |
| **STEM** | science, technology, engineering and mathematics |
| **TVET** | technical vocational education and training |
| **M2M** | machine-to-machine |

# EXECUTIVE SUMMARY

E&E manufacturing is one of ASEAN's most prominent sectors and a mainstay of economic growth, especially as the region moves up the value ladder and shifts away from low-cost production. Through rapid economic development and a rising middle class, the ASEAN region has also developed a broad industrial and consumer market for E&E machinery and goods. The sector directly employs an aggregate of more than 2.5 million workers in ASEAN.

Looking ahead, three disruptive technologies are likely to shape the E&E sector: robotic automation, 3D printing (also known additive manufacturing) and the Internet of Things (IoT).

Robotic automation in this sector is "human centric," occurring in the form of collaborative robots, or "cobots", able to perform repetitive, high precision and difficult tasks. This technology – also seen in the automotive sector – aids workers rather than replace them. Currently, people exceed the capabilities of robots in overall assembly, perception, flexibility, dexterity and adaptation to new duties, which means human workers are (for now) more cost-effective. However, this is changing. Compounded with predicted uptakes in 3D printing, displacement – particularly of lower skilled packaging and assembling jobs – is possible.

Opinions vary as to how quickly 3D printing can become cost-effective and useful for mass deployment. While its potential is undeniable, with some believing it could be deployed within the next ten years, 3D printing will primarily be used for highly customized, low-volume production. The key variance in our research participants' assessment of this technology was not "if", but "when" it will be prevalently adopted.

Unlike robotic automation and 3D printing, which threaten to displace workers, the IoT offers an important growth opportunity for ASEAN's E&E players. The IoT's ability to connect disparate operations, synchronize machines and generate insightful data presents exciting possibilities for enterprises to improve their efficiency in almost every sector. Because ASEAN's E&E sector and subsectors possess a formidable and established nexus of producers and suppliers, the world's high demand for IoT devices and components presents a significant growth opportunity.

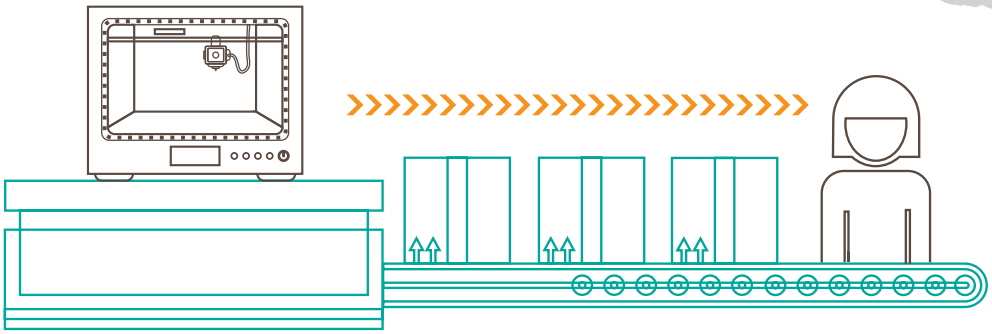
China's actions are also critical in how the E&E sector will develop in ASEAN. As China advances up the E&E value chain and enters higher skilled tiers of production, ASEAN countries are well positioned to absorb much of the lower skilled E&E jobs from which China is moving away, but mostly in the short term. Even though wages are rising in ASEAN, the region's lower labour costs are still more attractive.

Currently, over 60 per cent of salaried workers in Indonesia, the Philippines, Thailand and Viet Nam occupy E&E positions at high risk of automation. To capitalize fully on the sector's growth opportunity and foreign direct investments, policy-makers across the region urgently need to raise skills levels and innovatively connect skills providers to enterprise needs. In particular, more efforts are specifically needed to encourage women to pursue studies in science, technology, engineering and mathematics (STEM) disciplines to spur the availability of higher skilled labour.

Illustration 1 **ASEAN E&E overview**

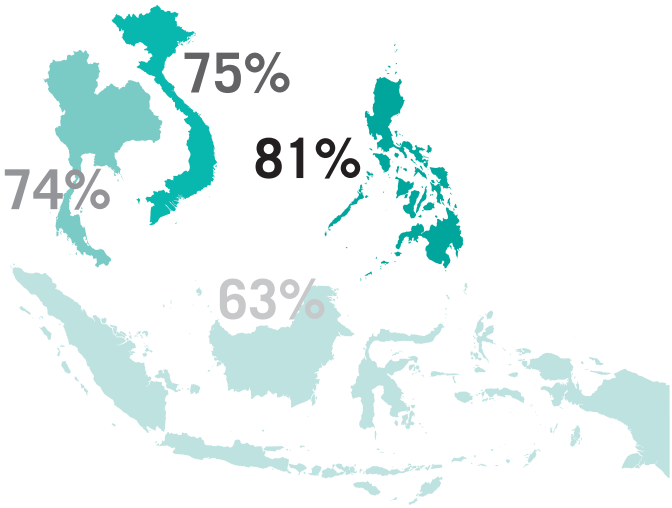
ASEAN's E&E exports
**almost tripled**
**over the past decade,** reaching
**US$382.1 billion** in 2014

**ASEAN**
directly employs
an aggregate of
over **2.5 million workers**
in the sector



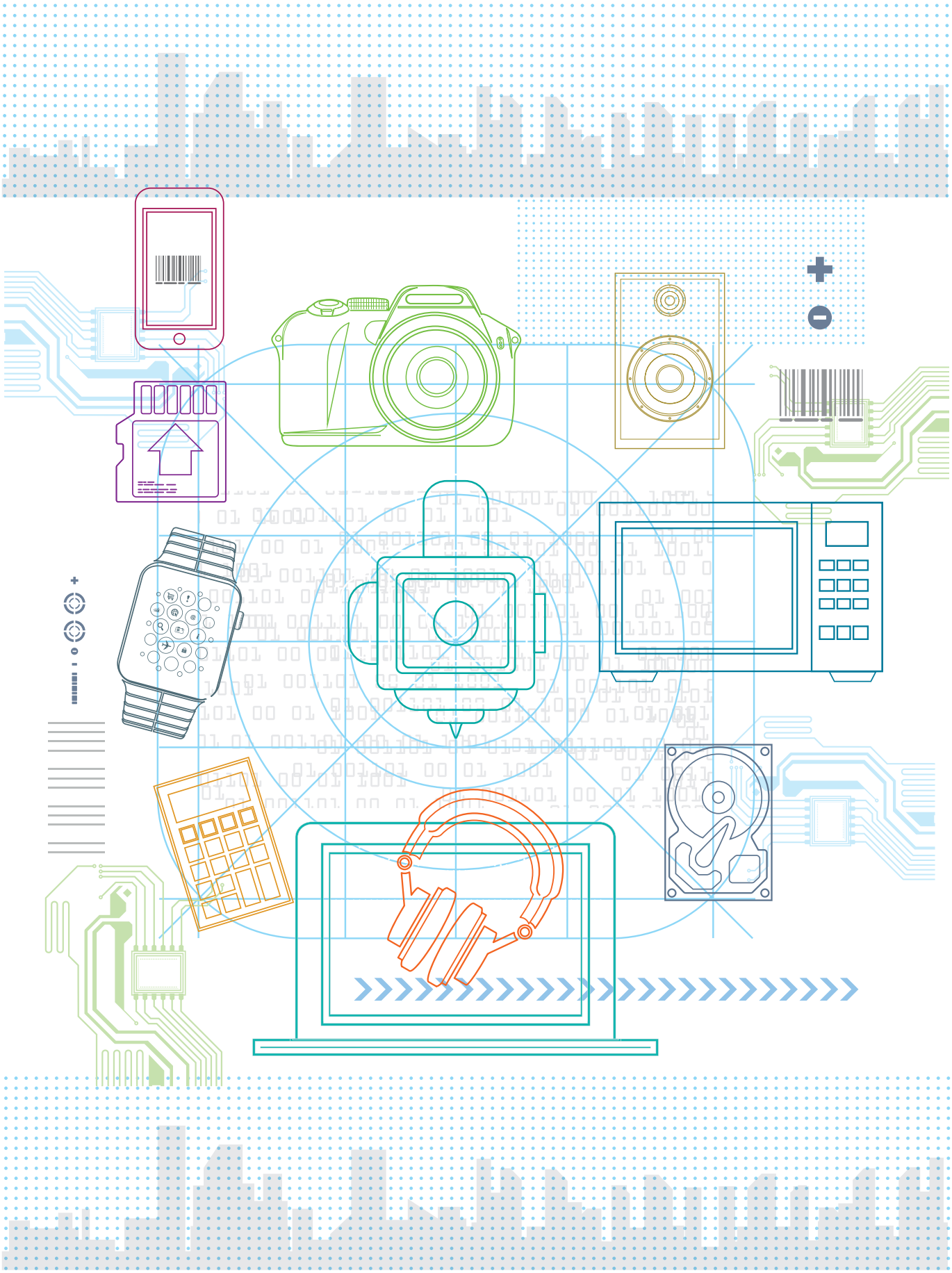
**Robotic automation, 3D printing and the Internet of Things are disruptive technologies globally**

**In ASEAN ROBOTIC AUTOMATION is currently replacing simple assembly, lower-skilled tasks**




**Over 60% of salaried workers**
in Indonesia, the Philippines, Thailand and Viet Nam **occupy E&E positions at**
**high risk of automation**

**China**
**is both an opportunity for ASEAN to scoop up lower-skilled jobs**
and a reason to
**invest more in technology**
to become more competitive



# SECTOR OVERVIEW

1

Electrical and electronics (E&E) manufacturing is a significant goods-producing sector. Its products vastly enhance human productivity and stimulate innovation across entire economies.

It would perhaps be more accurate to describe the E&E sector as a set of sub-sectors, yet even that fails to do justice to its enormity. From "white goods" (TV and household appliances) to "3C" electronics (computers, consumer and communications), these products shape most people's daily lives.

E&E is characterized by an integrated and diverse supply chain: Both small manufacturers and global titans participate in this industry.[1] The sector's supply chains are more geographically extensive and dynamic than in any other goods-producing sector. A single product can be the result of labour carried out by dozens of enterprises across multiple countries. One factor that makes this possible is the high value-to-weight ratio of electronic components and most final products, which makes long-distance shipping relatively inexpensive. For high-value components and some final products, such as notebook computers and mobile phone handsets, air shipment is common, thereby permitting supply chain integration from multiple locations.

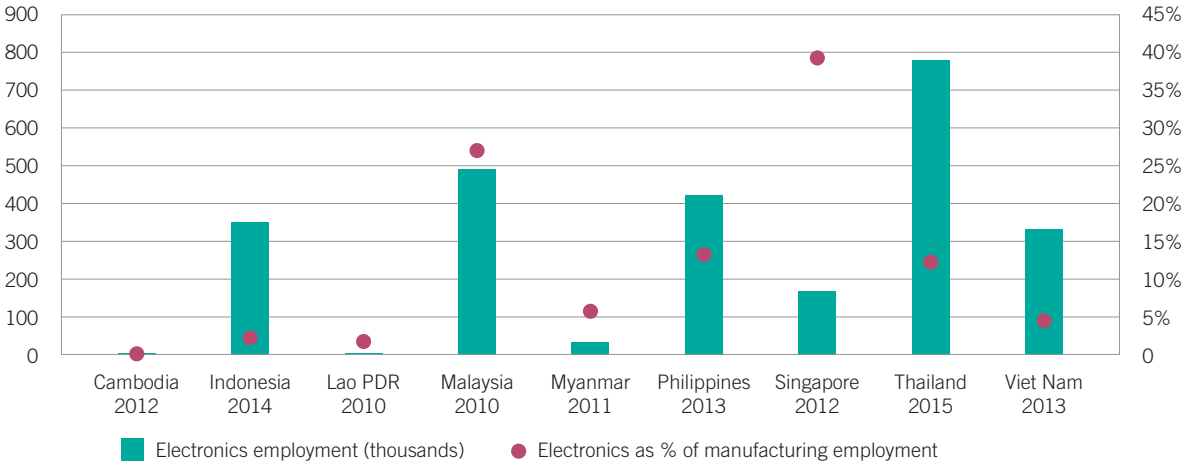
## E&E sector is ASEAN's power for growth

For ASEAN, E&E manufacturing is one of the region's most prominent sectors and a mainstay of economic growth, especially as the region moves up the value ladder in manufacturing and shifts away from low-cost production. Through rapid economic development and a rising middle class, the ASEAN region has also developed a broad industrial and consumer market for such E&E machinery and goods. The sector directly employs an aggregate of more than 2.5 million workers in ASEAN (see figure 1). Thailand's E&E employment was the biggest in 2015 in the region, encompassing approximately 780,000 workers and representing 12 per cent of the total employment in manufacturing. The industry encompassed the biggest share of total manufacturing workers in Singapore, accounting for 39 per cent of the total manufacturing workforce in 2012. E&E's prominence is observable in other ASEAN Member States: Malaysia, at 27 per cent in 2010 and the Philippines, at 13 per cent in 2013.[2] Mostly, E&E production in ASEAN focuses on components, such as integrated circuits (ICs), semiconductor devices and printed circuit boards (PCBs).

[1] The E&E sector includes three principal types of actors, sometimes referred to as "lead firms", "contract manufacturers", and "platform leaders". Lead firms produce the final E&E products consumers will commonly buy, typically sourcing their components and parts from a range of downstream manufacturers. Contract manufacturers operate further downstream and either provide components and modules to lead firms or deliver services to them such as design, software design, testing, supply chain management, distribution and assembly. Platform leaders might be lead firms or contract manufacturers but are distinguished insofar as their technologies – either hardware, software, or both – are widely adopted by others. Apple and Microsoft, for example, are both a lead firms and platform leaders. Intel, on the other hand might be considered a contract manufacturer but is also the computer industry's dominant platform leader.

[2] Among enterprises larger than 20 workers.

**Figure 1** **Total employment in manufacture of E&E products (thousands) and share of total manufacturing employment (per cent), selected ASEAN Member States, latest available year**

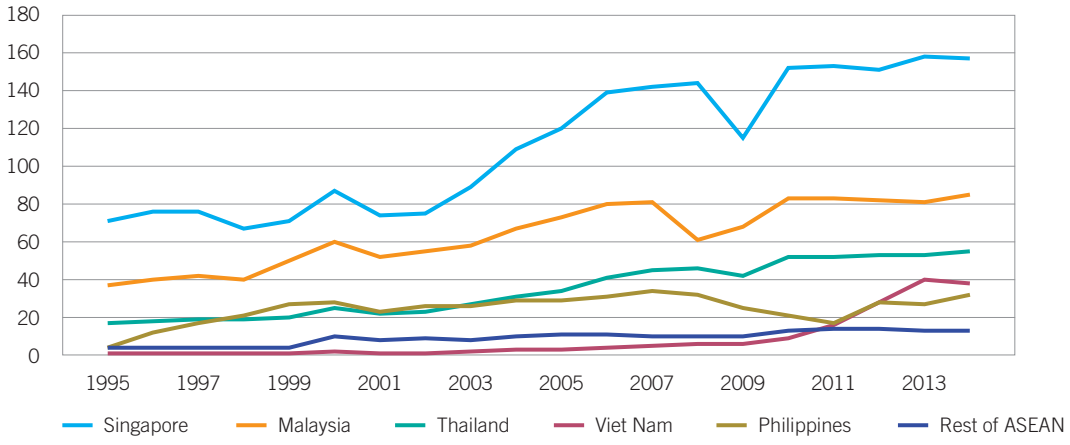



Note: E&E products include those under the International Standard Industrial Classification of All Economic Activities (ISIC, Rev.4) Divisions 26 ('Computer, electronics and optical products'), 27 ('Electrical equipment'), and 28 ('Machinery and equipment'). Total manufacturing refers to ISIC, Rev.4, section C, divisions 10-33.

Source: ASEAN, 2015; ILO estimates from official labour force surveys (various years).

Impressively, ASEAN's E&E exports almost tripled over the past decade, reaching US$382.1 billion in 2014.[3] Singapore is the region's clear frontrunner; the sector's total exports grew strongly throughout the 2000s, reaching US$157.5 billion in 2014 (see figure 2). Singapore's success has partly been driven by the rise of several giant E&E components manufacturers and electronics manufacturing services providers. For Malaysia and Thailand, E&E exports also saw significant growth over this time, reaching US$85.6 billion and US$55.0 billion, respectively, in 2014. It is worth noting that Viet Nam's exports increased rapidly between 2000 and 2014. Its compound annual growth rate accounted for 29 per cent, compared to that of Malaysia and Thailand of 3 per cent and 6 per cent, respectively.

**Figure 2** **Exports of E&E products (current US$ billions), selected ASEAN Member States, 1995-2014**



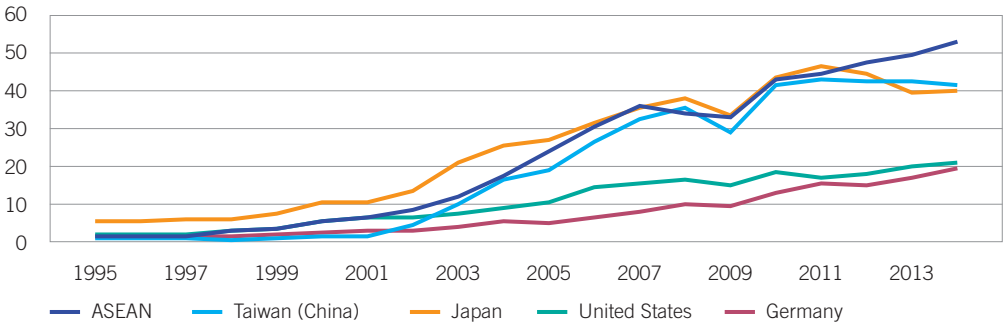

Note: E&E products include those under the Standard International Trade Classification (SITC), Rev.3, Divisions 75-77, 87 and 88. Manufactured goods refer to products under SITC, Rev.3, Sections 5-8 less Group 667 and Division 68.

Source: UNCTAD, 2016.

[3] In current US$.

Over 70 per cent of ASEAN E&E exports are shipped throughout Asia. In 2014, ASEAN E&E exports to Hong Kong (China), China and Japan accounted for 15 per cent, 14 per cent and 8 per cent of total E&E exports, respectively. Apart from Hong Kong (China), ASEAN dominates E&E exports to China, which is an assembly base importing several parts and components (see figure 3 and Appendix A for E&E trends in China). After Asia, the United States stands as the next largest importer of ASEAN E&E goods, accounting for over 11 per cent in 2014. Major ASEAN producers, including Singapore and Malaysia, only exported 23 per cent of their respective E&E products to the ASEAN region (this does not account for domestic consumption).[4]

**Figure 3 E&E part exports to China (current US$ billions), selected economies excluding Hong Kong (China), 1995–2014**




Note: E&E products include those under the SITC, Rev.3, Divisions 75-77, 87 and 88. Manufactured goods refer to products under SITC, Rev.3, Sections 5-8 less Group 667 and Division 68.

Source: UNCTAD, 2016.

## Why the sector is growing in ASEAN

ASEAN's diverse E&E activities make it an extremely attractive destination for manufacturers and investors. From high-tech design research and innovation to low-skilled assembling and packaging, each Member State brings its own strengths and specialties, allowing the region as a whole to cater to different E&E subsectors. Singapore's manufacturing fortes are ICs, semiconductor devices and PCBs. Viet Nam's allure lies in its low labour cost. Towards this latter point, ASEAN's competitive labour cost remains the primary attraction for many electronics manufacturers and a key pull factor for investment. Table 1 provides an overview of each ASEAN Member States' E&E specialties.



4 UNCTAD, 2016.

## Table 1 ASEAN E&E sector overview

| Country | Indonesia | Malaysia | Philippines | Singapore | Thailand | Viet Nam |
|---|---|---|---|---|---|---|
| **Key production** | IC, semi-conductor, PCBs | Semi-conductors, microchips, conductors, valves, household appliances, radio equipment, solar cells, PCBs | IC, semi-conductor, electronic data processing (PCBs, printers, hard disk) | Semi-conductors, silicon wafers, hard-disk components | Hard-disk drives, ICs, microchips, air conditioning units, refrigerators | IC, semi-conductor, PCBs |
| **Contribution to GDP (%)** | 2.1 (2014) | 9.8 (2014) | 13.8 (2013) | 5.3 (2013) | 15 (2015) | 23.4 (2014) |
| **Contribution to total exports (%) (2014)** | 7.0 | 36.5 | 52.2 | 41.2 | 24.1 | 25.4 |
| **Major export markets** | China and Japan | China, Hong Kong (China), Japan, Singapore and United States | Hong Kong (China), China, Japan, Republic of Korea and Taiwan (China) | China, Hong Kong (China) and Malaysia | ASEAN, China, Hong Kong (China), Japan and United States | China, Malaysia and Singapore |
| **Major players** | Toshiba, LG, Sony, Panasonic, Samsung | Bosch, Fairchild, Hewlett Packard, Hitachi, Silterra, Intel | Texas Instruments, Fairchild, Amkor, Toshiba, Epson, Fujitsu | Avago, Fairchild, Micron, Seagate, Hitachi, Flextronics, Sanmina, Lite-On, Wistron | Fujitsu, LG Electronics, Samsung, Seagate, Sony, Western Digital Bosch, Daikin, Electrolux, LG, Panasonic, Samsung, Siemens, Toshiba | Intel, Microsoft, LG, Panasonic, Samsung, Hitachi, Active-Semi, Hanel, Fuji, Xerox |

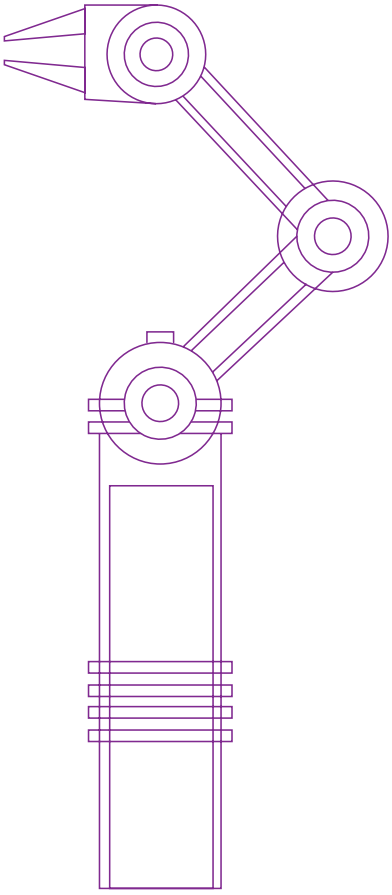
Source: ASEAN, 2015; Brown, 2015; GBG Indonesia, 2013; HKTDC, 2015; Hidayat, 2016; MATRADE, 2016, Philippines Board of Investment and Department of trade and Industry, 2011; Thailand Board of Investment, 2015a; Thailand Board of Investment, 2016; Singapore Economic Development Board, 2016; ILO estimates from official labour force surveys (various years), Oxford Business Group, 2016; UNCTAD, 2016; VIETRADE, 2015; World Bank, 2016.

Table 1 also depicts the widespread manufacturing presence of major E&E multinational enterprises (MNEs) that are global leaders for patent filing and protecting their technological innovation. Of the top 30 international patent applicants worldwide, 23 came from the E&E sector (and of that, 20 from MNEs in the Asia and Pacific region), including Panasonic (Japan), Canon (Japan), Samsung Electronics (Republic of Korea), LG Electronics (Republic of Korea), Huawei (China), ZTE (China) and Sony (Japan), among others. Globally, the World Intellectual Property Organization reports that E&E sector has the most patent activity compared to other sectors with "computer technology", and "electrical machinery, apparatus and energy" as the two fields that experienced the largest numbers of patent filing in 2013.[5]

While the sector is characterized by a wide diversity in terms of the entirety of the production process, much of the production is still low-skilled and low-value in ASEAN. In the E&E sector, manufacturing is the least value-added activity while research and market exploration are of the highest value-added activities (see Appendix B for E&E characteristics and trends per ASEAN country).

This chapter examines how technological innovation impacts the E&E sector in ASEAN and their related effects on enterprises and the workforce. Our findings are based on 73 industry interviews conducted in four ASEAN countries along with expert consultations.

## 1.1 The disruptors



**Robotics and automation.** Our research shows that the E&E sector is highly susceptible to automation and is showing a significantly increased appetite for robotic consumption. As a sector, the E&E industry is the second largest consumer of industrial robots and this trend is likely to continue.[6] Globally robot sales to the E&E sector increased by 34 per cent in 2014, establishing a new high peak.[7] The increasing demand for electronic products and integration of electronic components in other sectors as well as the need to automate production in countries with low production capabilities were seen as the driving factors for an accelerating demand.

Asia currently dominates the global industrial robots market for E&E manufacture in terms of sales volume as well as annual revenue. It also holds the strongest growth potential for the future market in robotics, with China and ASEAN countries expected to be the driving engines for the growth.[8]

According to the Boston Consulting Group (BCG), there are four industry groups that will account for 75 per cent of global robot installations in 2025: (1) computers and electronic products; (2) electrical equipment, appliances and components; (3) transport equipment; and (4) machinery. More surprisingly, BCG indicates that at least 85 per cent of the production tasks in these industries are automatable. It is expected that countries with heavy concentrations of automatable industries, comparably higher labour costs and limited employment protection for job cuts will aggressively implement automation technology. BCG also notes that a country's motivation to adopt robots is partially influenced by desires to achieve international standards for product quality, as seen in the case of Indonesia.[9]

5 WIPO, 2015.

6 IFR, 2015.

7 Including computers and equipment, radio, TV and communication devices and equipment and medical, precision and optical instruments.

8 Research and Markets, 2016.

9 Sirkin, Zinser and Rose, 2015.

BCG expects aggressive adoption will come from countries like Indonesia and Thailand, which have heavy concentrations of the industries that are capable of high levels of automation and higher labour costs than some of their low-wage competitors.[10]

> "Many enterprises in Malaysia's electronics manufacturing sector didn't see a need to invest in productivity-enhancing automated technologies within the short-term given such competitive wages. However, the national minimum wage introduced in Malaysia in 2013 provided a greater incentive to invest in precisely those kinds of technologies."
>
> Dato' Palaniappan, Director, Panasonic Appliances Air-Conditioning, Malaysia, ILO interview, 2015.

The introduction of automation in certain areas of production allows for increased productivity and quality of the final product. This is particularly the case for repetitive tasks. It is important to emphasize that current deployment of robotics in the E&E sector is concentrated on low-cost robots that can conduct simple assembly tasks, which do not require high precision.[11] Our interviewees stressed that for some tasks, particularly those that consist of greater product complexity, robotic implementation is still difficult and misjudged implementation can be very costly.

The wide-spread application of robotics in the E&E sector is being witnessed in China's Henan province, which is the third largest global mobile phone producer thanks to the construction of the Foxconn factory. Foxconn's Zhengzhou factory in Henan produces 70 per cent of all iPhones, employs 300,000 people and produces an estimated 200,000 phones per day.[12] In 2011, Terry Gou, the chief executive of Foxconn, announced a company-wide plan to replace a significant number of workers with robots to better manage rising labour cost and unsafe working conditions.[13] Within five years, Foxconn is reported to have replaced 60,000 workers with robots in a single factory.[14] While not as disruptive as the Foxconn example, our research indicates that enterprises in ASEAN are similarly exploring automated solutions to weather continued increases in labour costs.

Our interviews show that when automation occurs in the E&E sector, it is often "human centric", also referred to as "autonomation" or semi-automation. This technology – also seen in the automotive sector – aids a worker rather than replaces them. Collaborative robots, or "cobots", can be taught to work alongside workers. This may change as cobots become more sophisticated, but in the meantime, real workers have advantages when it comes to adaptability and perception while cobots can replace more repetitive and difficult to reach processes.

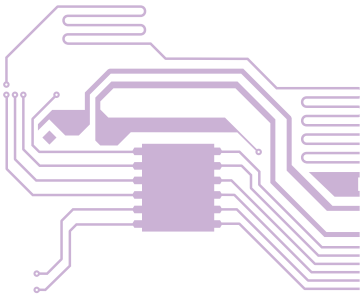
10 Ibid.

11 IFR, 2015.

12 Epstein, 2013; Chang, 2015.

13 The Economist, 2011.

14 Wakefield, 2016.



Rethink Robotics, a Boston-based company produces a cobot named Sawyer with a base price of US$29,000. Sawyer is designed for machine tending, circuit board testing, and other precise, repetitive tasks, specifically those that take place in the middle of a long assembly line of electronics products. There's a huge need for cobots that can do tasks like these, especially in Asia, which is a target market for Rethink.

Source: Tobe, 2016.

There is plenty of evidence that supports the claim that electronics manufacturers and electronics manufacturing services companies – enterprises that test, make, distribute and repair components for the original manufacturers – are expanding their use of cobots. According to those in the industry, cobots are easy to program and control, and cost approximately US$25,000, which is less than their conventional equivalents.[15]

"The industry is getting competitive. Adoption of technology helps manufacturers to remain competitive in the market and meet end-used demand…technological adoption is important to scale up production with accuracy."

Luke Mendoza, Vice President of Head-Value Engineering, Integrated Micro-Electronics Inc., the Philippines, ILO Interview, 2015.

At the global level, the likes of Siemens have established an automated electronics plant producing programmatic logic controls in Amberg, Germany. Automated machines and computers handle 75 per cent of production and production quality is at 99.9 per cent.[16] Siemens also opened a similar automated factory in Chengdu, China in 2013 to produce closer to consumer markets. With more automated machines than ever before, the plant is able to produce seven times as many units compared to 1989 with approximately the same number of workers.[17] It is difficult to envisage Siemens next move to duplicate the original Amberg plant; however, the company's manufacturing presence in ASEAN countries like Indonesia, Malaysia, Singapore and Thailand and operation of an ASEAN-Pacific Engineering Graduate Programme to provide tailored training, point towards Siemen's investment in the region and likelihood to expand sophisticated automated production in ASEAN plants.[18]

**3D printing, also known as additive manufacturing.** This involves processes to make physical objects, usually through successive layers of materials applied under a computer's control. They are currently less prominent in the E&E sector in comparison to other manufacturing industries. Nano-scale computer parts, such as processors, are difficult to assemble with additive manufacturing as they require combining several electronic components together and furthermore, numerous components are synthesized from multiple materials. Therefore, mass additive printing (as opposed to additive manufacturing) of integrated electronic components, such as circuit boards, will likely comprise the next stage of this technology.

15 Jenkins, 2016.

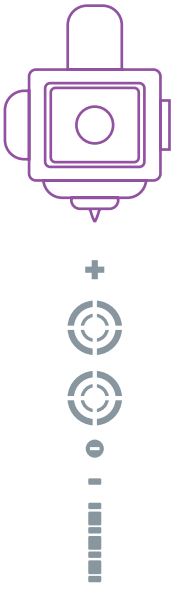
16 Siemens, 2014.

17 Ibid.

18 Siemens, 2013.

As for the swiftness with which 3D printing will disrupt, opinions differ. Some analysts believe that manufacturing will fundamentally change quickly. According to this view, the traditional approach – manufacturing different components and then assembling them together – would be replaced by singular, one-time printing. Indeed, reports show that 3D printed circuits will be commercially available by 2018, with 3D-printed electronics becoming more widespread than PCB production solutions.[19]

Others believe 3D will present a very small challenge to Asian manufacturing and impose less dramatic employment consequences in the short term. Drawing from the evolution of 3D printing in other industries, the impact, according to this view, is likely to be limited to very low volume prototyping or deployed to perform unsophisticated tasks (for example, the method by which antennae are added to mobile phones).

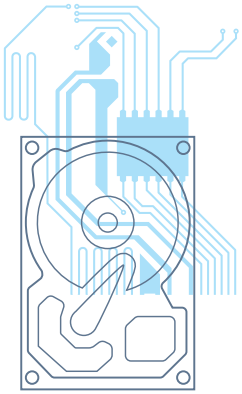


> "There are still too many significant technological hurdles to overcome before volume 3D electronics manufacturing is either fast or cheap enough to serve as a replacement technology. In ten years things might start to look different with the ability to print multi-material functional objects, but still this will be low volume, customized, complex products. In summary it's [3D printing] a new technology that will take some time to drive any significant change in the ways things are done."
>
> Simon Fried, Chief Brand Officer and Co-Founder, Nanodimension, ILO interviews, 2016.

Moreover, deploying 3D printing throughout ASEAN's E&E sector will require a supply of highly skilled workers. Therefore, the disruptive impact of this, especially for ASEAN, is currently up for debate. In any case, 3D printing's future adoption should not be a surprise – there is no dispute about whether 3D printing will become prevalent or not. The real debate is when.

## 1.2 Forces at play

### Other sectors are driving innovation within E&E



> "Export will definitely increase to meet the growing demand coming from different fields. Currently, the demand is coming from consumer application which will saturate soon and the new demands will come from automotive, renewable and power sectors."
>
> Arjun Kanthimahanti, Vice President for Technology Development, Silterra, Malaysia, ILO interview, 2016.

[19] Rasmussen, 2015.

The E&E sector is becoming increasingly connected to every economic industry, whether directly or indirectly, and advances in these industries' products are driving further activity within E&E. Consider the automotive sector. Electronics have become an indispensable element of the modern automobile and are present in various systems including: power or engine controlling systems, security, safety systems, driver assistance, diagnostic systems, passenger comfort, information systems, and in-car entertainment. The value of global automotive electronics is forecasted to reach US$314.4 billion within 2020.[20] Moreover, as highlighted in the automotive and auto parts paper, carmakers are working on making their vehicles either fully or partly self-piloting. As cars become increasingly technologically advanced and electrified, ultimately leading to driverless models mainstreamed within ten or 15 years in developed economies, these two sectors are likely to become more intertwined.[21] Apple, which is understood to be planning an electric car, may try to outsource to a contract manufacturer to have them made, as it does with its iPhones.[22]

> "The demands for ICs are expected to grow at a faster pace. Demand for consumer devices might reduce, but regular appliances are turning into smart devices which will drive the market of ICs in the coming years."
>
> Mulia Ali Akbar, Engineering and Technology Development Manager, PT. Unisem, Indonesia, ILO interview, 2016.

Other sectors are similarly upgrading their products. The clothing and footwear sector, for example, offer a huge array of advanced goods, from smart bras that monitor users' fitness to electronic shoes that provide navigation instructions.[23] Examples from retail include "smart packaging" and new possibilities for interactive advertising.[24] These advances are sure to drive activity – and therefore, employment – in the E&E sector.

## The rise of the Internet of Things

Related to this force at play, but deserving extended discussion, is the Internet of Things (IoT), which has been identified as one of the most disruptive innovations by numerous reports. For enterprises, the IoT promises to connect objects across the value chain in order to facilitate data collection, data exchange, remote monitoring and better decision-making. It can optimize production processes, enhance workers' productivity and even reduce global rates of workplace injuries in manufacturing.[25] A critical component of an IoT device is an electronic sensor, and analysts predict that devices connected by electronic sensors will grow from

20 Thailand Board of Investment, 2015a. Automotive electronics are a subsystem which primarily consists of semiconductor devices. It basically functions in three steps to incorporate different features in the car, in other words sense, compute and actuate. While safety would not be possible without electronics, development of infotainment segments (for example, navigator, in-car multimedia, Bluetooth and GSM) has played a vital role in driving the demand for E&E items.

21 For example, Ford teamed up with Amazon to connect its cars to sensor-laden smart homes. BMW, Daimler and Volkswagen's Audi division jointly purchased "Here", a mapping service to make sure that carmakers have an independent provider and do not depend on Google Maps. GM also announced a US$500 million investment in Lyft, a ride-sharing service (The Economist, 2016).

22 The Economist, 2016.

23 For example, OMSignal (2016) and Lechal (2015).

24 For example, Evrything (2016) and Ambasna-Jones (2015).

25 CEA, 2015; Bank of America Lynch, 2015.

around 10 billion today to as many as 30 billion devices by 2020.[26] Other advancements are triggering the rise of the IoT. These include: the steep decline in cost of sensors; bandwidth and processing; the availability of big data analysis; and the connectivity of smartphones to home appliances and consumer devices.[27]

The Internet of Things connects devices such as everyday consumer objects and industrial equipment onto network, enabling information gathering and management of these devices via software to increase efficiency, enable new services, or achieve other health, security or environmental benefits.

Source: Goldman Sachs, 2014.

Research shows that the IoT is expected to open significant opportunities for semiconductor companies by stimulating demand for sensors, connectivity and memory. The IoT may even fuel the semiconductor industry to surpass its global annual revenue increase of three to four per cent over the last decade.[28] This represents a direct growth opportunity for semiconductor players in ASEAN that dominate global production. Indeed, ASEAN itself is becoming better connected to take advantage of the IoT. The ASEAN Smart Network Initiative, has pledged to invest US$13.6 billion towards building smart grid infrastructure across the region by 2024.[29]

With regard to the introduction of more advanced products such as self-driving cars, smart clothing and IoT integrated consumer devices, production in E&E will be catalysed, and this will push the E&E sector to produce more innovative products, thereby leading to potential increased employment. However, assembling these more complex, higher-value products will require higher skill levels.

Unfortunately, there is enough evidence that indicate ASEAN's insufficient investment in education and skills can limit the region's E&E's growth, particularly for high value-added activities.[30] The lack of strong human capital development policies, including weak frameworks for both schools and universities, discourage the industry's structural transition from low to high value-added activities. For example, in Malaysia, inflows of migrant workers have helped keep wages from rising and helped maintain much of the country's lower skilled assembling and packaging work. However, this policy, coupled with a weaker investment in human capital, has also restricted Malaysia's growth in higher-value activities and constrained technology upgrades.[31]

26 IDC, 2014.

27 Goldman Sachs, 2014. Sensor prices have dropped to an average US$0.60 from US$1.30 in the past 10 years, while bandwidth and processing cost have declined by nearly 40 times and 60 times, respectively, during the same period. Bauer, Patel and Veira, 2015.

28 Bauer, Patel and Veira, 2015.

29 Glan, 2015. Smart grids apply digital processing and communications to power grids on a large scale, merging data flow and information management with traditional power supply. They also automate key functions of existing grids to make them more efficient and reliable over time. Smart grids are widely seen as an enabler for consumer appliances and industrial machines making up the IoT.

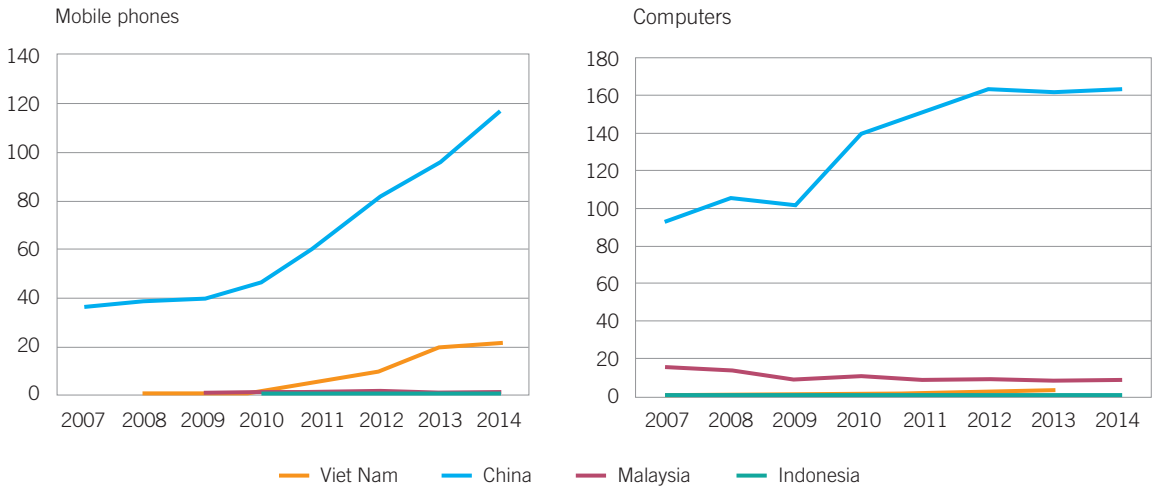
30 Cheong Selvaratnam, and Goh, 2011. While the ILO defines high-skill occupations consisting of International Standard Classification Occupations (ISCO)-08 major group 1 (legislators, senior officials and managers), major group 2 (professionals) and major group 3 (technicians and associate professionals), for the purposes of this paper, high-skill occupations are extended to cognitively intense and non-routine jobs. The ILO defines low-skill occupations as consisting of ISCO group 9 (elementary occupations), for the purposes of this paper, low-skill occupation extends to occupations that are labour intensive and routine such as machine operators.

31 Rasiah, forthcoming.

## China's force in the E&E sector remains prominent

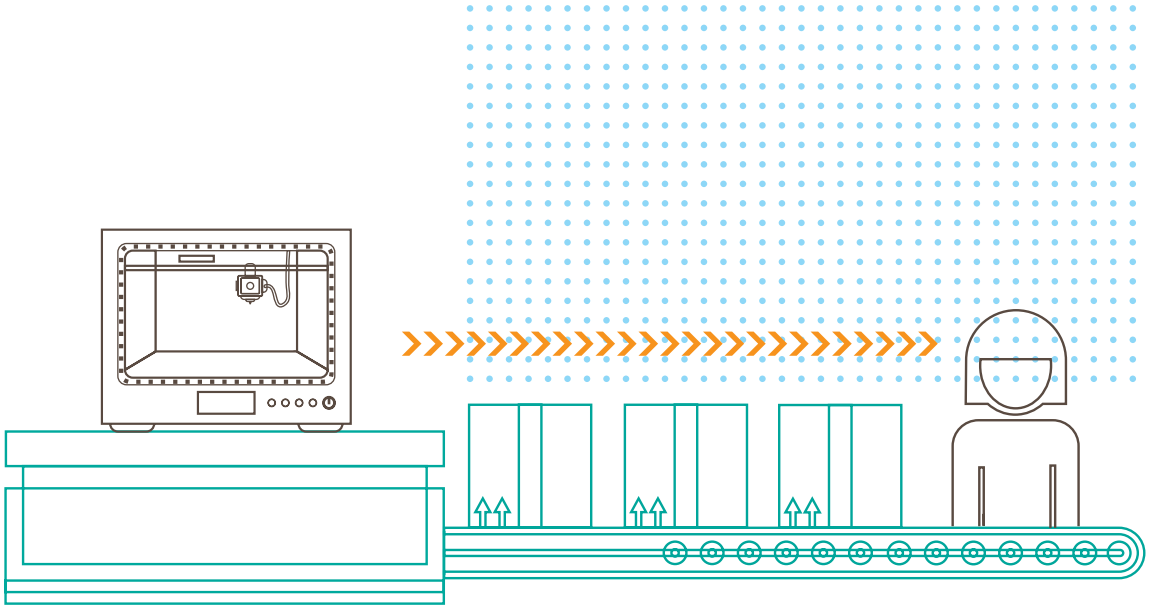
Opportunities to increase production, and thus employ more workers, may arrive due to China's movement up the value chain. As figure 4 shows, China currently outpaces ASEAN in terms of E&E exports by a large margin. From white goods to consumer electronics, production increases and market growth over the past 20 years have helped China establish itself as the largest, most developed production ecosystem in the world. In 2014 the electronics sector contained 34,034 industrial enterprises that produced over 1.6 billion mobile phones and exported a total of US$859 billion in electronics and electrical products.

**Figure 4** **Exports of mobile telephones and computers (3C) (current US$ billions), selected ASEAN countries and China, 2007–2014**




Note: Mobile telephone data were not available for the Philippines. Mobile telephones and computers include those under the SITC, Rev. 3 Divisions 7641 and 7522.

Source: UN Comtrade, 2016.



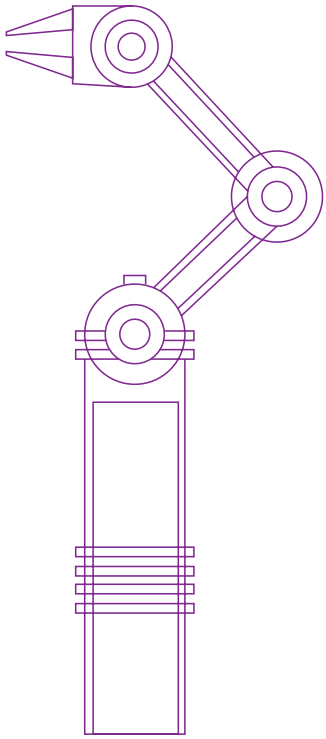
> "With technology adaptation growing in the Philippines, more and more high-value items are being produced. Japanese manufacturers are also starting to look at the Philippines as a viable supplier base."
>
> Rick Modina, Senior Vice President for Operation, Ionics EMS, Inc., the Philippines, ILO interview, 2016.

However, as China moves up the value chain, opportunities may be provided in the short term for ASEAN's E&E enterprises. Many analysts and industry leaders have suggested "the end of cheap China" is arriving, and because of this, ASEAN can scoop up lower skilled work. In the medium term, ASEAN can also connect to increasingly sophisticated production processes. Proximity to China in terms of producers, suppliers and consumer market is a critical opportunity upon which ASEAN needs to capitalize.

> "99 per cent of parts for 3C goods can be sourced in Guandong province, let alone China."
>
> Former Director, Electronics Hardware and Software MNC, Shanghai, China, ILO interview, 2016.

It is important to note that labour costs are not the sole determinant for relocation. Many experts argue that China's vast and expansive material supply chain – in both raw materials and supply of components parts – and highly integrated clusters of suppliers make the industrial ecosystem unrivalled. Moreover, its skilled labour pool and the power of the domestic market, make relocation decisions complex.

> "In order to replace humans at the assembly stage, robotic investment would have to be huge."
>
> Associate Director for Industrial Automation, IHS Research, ILO interview, 2016.



There is some evidence of ASEAN poising itself advantageously already. Singapore's R&D budget for 2011-2015 increased by 20 per cent from the previous five years, creating opportunities to integrate modern and advanced machinery into its operations.[32] Seven of Thailand's provinces consist of the electrical appliances, electronics and telecommunication clusters that link manufacturers, suppliers, supporting industries, research institutions, academic institutions and public organizations.[33] Similarly, in Viet Nam, the Saigon Hi-Tech Park houses major electronics manufacturers such as Intel, Samsung, Canon, LG and Panasonic; these manufacturers are given preferential treatment regarding land leases and taxations. Viet Nam has also instituted stimulus programmes, such as Viet Nam's National Technology Innovation Fund.[34] Such clusters and financial investment form an ecosystem that can be further enriched, thereby securing E&E's prominence in the region.

32 Singapore Economic Development Board, 2016.

33 Thailand Board of Investment, 2015b.

34 Viet Nam's National Technology Innovation Fund provides grants and lends capital to implement scientific and technological projects proposed by enterprises and individuals.

## Integrating technology comes with challenges

While strengthening its supply chain infrastructure provides a competitive first step for ASEAN, several challenges should simultaneously be recognized.

First, the E&E industry is a high-tech manufacturing sector, and therefore, requires a large amount of capital investment for initial development, resulting in relatively higher entry and exit costs than others sectors, like the garment industry. Additionally, E&E's expensive equipment cannot be easily relocated. Thus, with China's available skilled labour pool, established E&E ecosystem and the power of its domestic market, relocation decisions from China will be complex, meaning ASEAN will really need to position itself favourably if it wishes to secure investment from China.

The interviewees from the E&E sector also voiced that poorly executed automation can result in vast losses for the factory. For example, if people are working on an assembly line and a problem occurs, the process can be easily stopped and adjusted. However, if there is a small programming error in a machine, which is likely if proper training is not provided, then a whole production run can be ruined, leading to a vast number of defective goods and large amounts of material waste.

> "Automation done wrong can be very, very costly."
>
> President, China Factory Improvement Consultants Co. (China, Shenzhen), ILO interview, 2016.

Additionally, short product development cycles and product lifespans need to be accounted for. Because many enterprises release a new version in a product series every one to two years (and discontinue old ones), there exists little incentive to invest in automation equipment for specific models. This is particularly the case within the 3C industries. Taking mobile phones as an example, product turnover is so high that the return on investment (ROI) would have to be guaranteed to purchase technology that cannot be reused in newer models. An enterprise must be assured of a long-term gain to implement automation – something difficult to achieve with a short product lifespans. In this case, human perception, flexibility, dexterity and adaptability make them preferable over machines for the time being due to high product turnover. With larger, less complex items such as white goods, the levels of automation are higher due to the consistency of the core components. In these cases, automation investment makes more sense.

Given that full automation is not always preferable, this means that low-cost labour will primarily drive ASEAN's E&E sector for now. However, efforts, such as government policies incentivizing skills upgrading, should nevertheless be pursued help the industry remain competitive in the long term.

# IMPACT ON ENTERPRISES

## 2.1 Effects on operations

### Incremental technological advancements have not yet reached a tipping point

Mostly, technology advances incrementally, and sectors absorb it at different speeds until a critical point is reached, whereupon significant labour displacement occurs. For E&E, technology is well developed and it is feasible to automate many tasks. However, it is clear from many enterprises interviewed that the cost matrix has not reached a tipping point to elicit wider labour displacement yet. This cost matrix is affected by factors such as short product lifespans, the difficulties of relocating machines, the risks of large-scale errors from machines and human superiority over robots in assembly processes. Thus, in ASEAN, manual work will likely continue in the short and medium terms. Enterprises should be proactive and prepare for the inevitable tippint point, though.

### Goods are increasingly showcasing more electronic capabilities, which will stimulate E&E activity

As aforementioned, other sectors are increasingly incorporating advanced technology in their products. With the rise of goods such as wearable devices and the IoT, E&E activity in ASEAN is likely to continue growing, and increased job opportunities can be expected.

## 2.2 Effects on skills

Unanimously, our research respondents report that higher skills will be needed more frequently. As products for the consumer and robots for enterprises become more advanced, E&E sectors in ASEAN will need to accommodate higher-value production and higher skilled assembly work.[35]

In Malaysia, for example, increasing automation and demand for knowledge-based activities since the late 1980s have created a capital and knowledge intensive E&E sector, where technical skills are sought by employers. However, the E&E sector experienced a reduction of knowledge-based chip assembly since 2010 due to a higher demand for technical personnel, which was not met. Malaysia-based enterprises interviewed emphasized the need for higher skill sets and reported that high-value manufacturing has moved to countries like China and Viet Nam as a result of both lack of skilled engineers and the relatively high cost of hiring them. As a result, E&E manufacturers in Malaysia today are focused on low-value production and employ low-skilled assembly workers.[36]

35 A prime example is Viet Nam, where most E&E factories are focused on low-value production and low-skilled assembly work.

36 Malaysia has relied on low-skilled foreign labour for the past 10 years to boost the growth of the E&E industry. In fact, in 2013, foreign workers accounted for almost 35 percent of operators in the semiconductors industry in Malaysia (according to unpublished data supplied by the Department of Statistics of Malaysia).

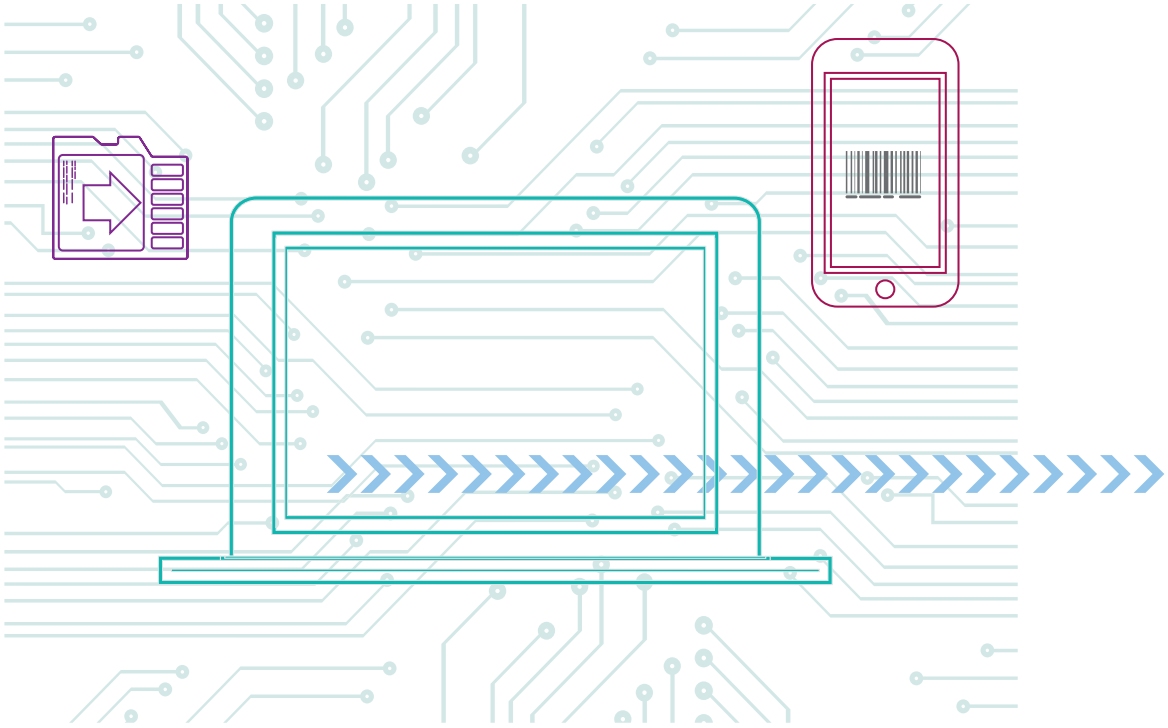
"Adoption of new technology leads to new opportunities and challenges. With new technologies, we need more skilled employees. And with the adoption of the latest technologies, more job opportunities can be expected in particular in the sectors such as IC design firms and fabless companies."

Arjun Kanthimahanti, Vice President of Technology Development, Silterra Malaysia Sdn. Bhd, Malaysia, ILO interview, 2016.

Strong technical, engineering, science and overall manufacturing skills will become evermore important as the sector evolves and absorbs new waves of technologies such as the IoT and nano-technology. The use of foreign labour and relocation of E&E production processes demonstrate that human capital is not developing effectively to meet the demands of a dynamic E&E sector. In order to upgrade technology and factor in automation, purchasing of robots and machinery is not enough. There is still considerable work to be done from a management and operations perspective to ensure robots and machinery are optimised. Higher skill sets and commitment are required to achieve this.

"With the adoption of technologies, technical skills are required to manage or handle new machineries."

Roger Foo, Director, Fairchild Semiconductor Sdn. Bhd., Malaysia, ILO interview, 2016.



# IMPACT ON PEOPLE

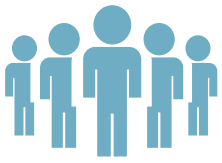
3

The E&E sector is expanding in ASEAN, and additional growth and employment will occur. In the short-term, developing and emerging economies will continue to attract investment in lower-skill activities such as packaging and assembling; however, in the medium to longer term, these jobs will be automated.

On this latter point, our research shows high automation risk for occupations in the sector. For Indonesia, the Philippines, Thailand and Viet Nam, a respective 63 per cent, 81 per cent, 74 per cent and 75 per cent of salaried workers in the sector face this high risk of automation, as these positions consist of repetitive, non-cognitive tasks.[37] Therefore, current workforce must be agile in upgrading its skills and capabilities. Carrying out this recommendation, admittedly, may prove difficult, as the current quality of technical vocational education and training (TVET) and other institutions remains a concern. Within TVET institutions, the quality of teaching, lack of certification frameworks, and static curricula with limited relevance to modern and fast changing enterprise needs are noted impediments to wider growth.

In the accompanied student survey, students were asked to consider the economic sector they would most like to work in after graduation. The E&E sector was not among the most desired sectors. The most desired sectors were financial or insurance services, closely followed by information and communications services, and then arts, entertainment and recreation services. As of 2014, social sciences, business and law were the most popular fields of study in all ASEAN countries.[38] For the E&E sector to grow and keep up with the pace of technological development, it's clear that major efforts are needed to encourage more students to take STEM related courses.[39]

Furthermore there is a need for greater promotional efforts to get female students studying STEM subjects and pursing employment in the E&E sector. For example, the top three subjects that women in ASEAN countries enrolled in were education, health welfare and humanities. A greater proportion of women students in ASEAN desire to work in human health or social work while more men desire a job in scientific or technical research. Science (including engineering) was a male dominated subject of study in all ASEAN countries except Brunei Darussalam, Malaysia, Myanmar and Thailand.[40]



37 Chang and Huynh, 2016.

38 UNESCO-UIS, 2016.

39 For example initiatives such as the Higher Engineering Education Alliance Program in Viet Nam are helping update the country's engineering and technical vocational schools (HEEAP, 2016).

40 But encouragingly female enrolment in tertiary education was relatively high in Brunei Darussalam, Malaysia, Myanmar, Singapore and Thailand, accounting for more than 50 per cent of average enrolment in tertiary education ASEAN (Cambodia had the lowest rates of female enrolment in tertiary education) (UNESCO-UIS, 2016).

# LOOKING AHEAD

4

### Automation and robotics will increasingly pervade the industry, and low-skilled jobs in assembling and packaging will face risk of displacement

- Automation and robotics are, and will continue to, increase across the E&E sector.
- Incrementally, low-skilled workers will be required less and less as robots become more efficient and advanced. Eventually, these workers will encounter risk of being displaced.
- 3D printing could become the major disrupter to the industry with many predicting wider use within 2025. The implications for employment are large, as the ability to print multi-material objects will streamline production. 3D printing is highly significant to the future of the industry.

### Targeted policy focus on education and skills is essential to climb the value chain

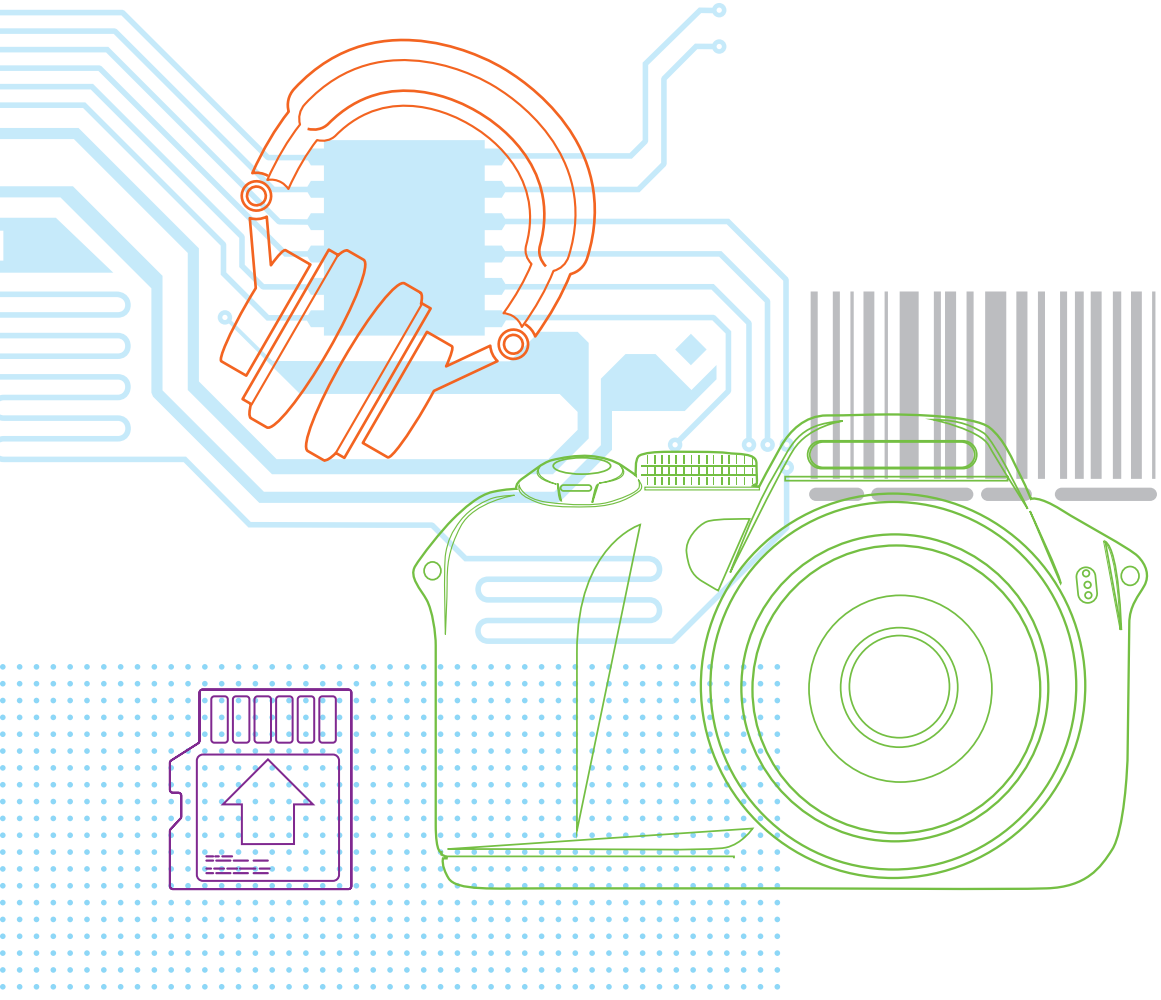
- As more factories move to automation and robotics, the availability of higher skilled labour is becoming more important, and this will drive investment decisions.
- Failure by governments in the region to invest sustainably and innovatively in skills and education polices will transpire in foreign direct investments (FDIs) going to other countries.
- To scale up the value chain, investment is needed in the fields of science and technology in related electronics specializations and frontier research. Science parks (for incubation) and research universities (for basic R&D) are important corollaries to support new generation technologies that can spur new cycles of innovation.
- Competing on price (for example, low wages), has been a useful investment and development strategy. However, it is not a sustainable one. The calculus has changed. Policy-makers need to look through a longer term development lens, especially in skills and education.
- Traditionally, education and skills are slow moving policy areas. It can take years to see demonstrable changes in behaviour and outcomes. New ways of thinking and new delivery mechanisms are needed.

## The industry will grow and become more sophisticated with growing employment opportunities

- In the short term, there will be a marked increase in machine-to-machine (M2M) communication, which refers to the interactive connectivity and interoperability among machines. M2M will operate across the wider manufacturing sector and in consumer-end products.

- There will be market growth through new consumer electronic devices, such as wearable technology and increased connectivity among homes, cars and other products. Wider sectoral impacts such as healthcare and transport will be observed.

- Acceleration in the interconnectedness between E&E and other growth sectors in the region, especially the auto sector, will come. The automotive industry is seeing a huge level of growth in the amount of electronic input within vehicles. The demand for automotive electronics will continue to be a strong driver as demand for vehicles with enhanced performance, comfort, safety and other factors.



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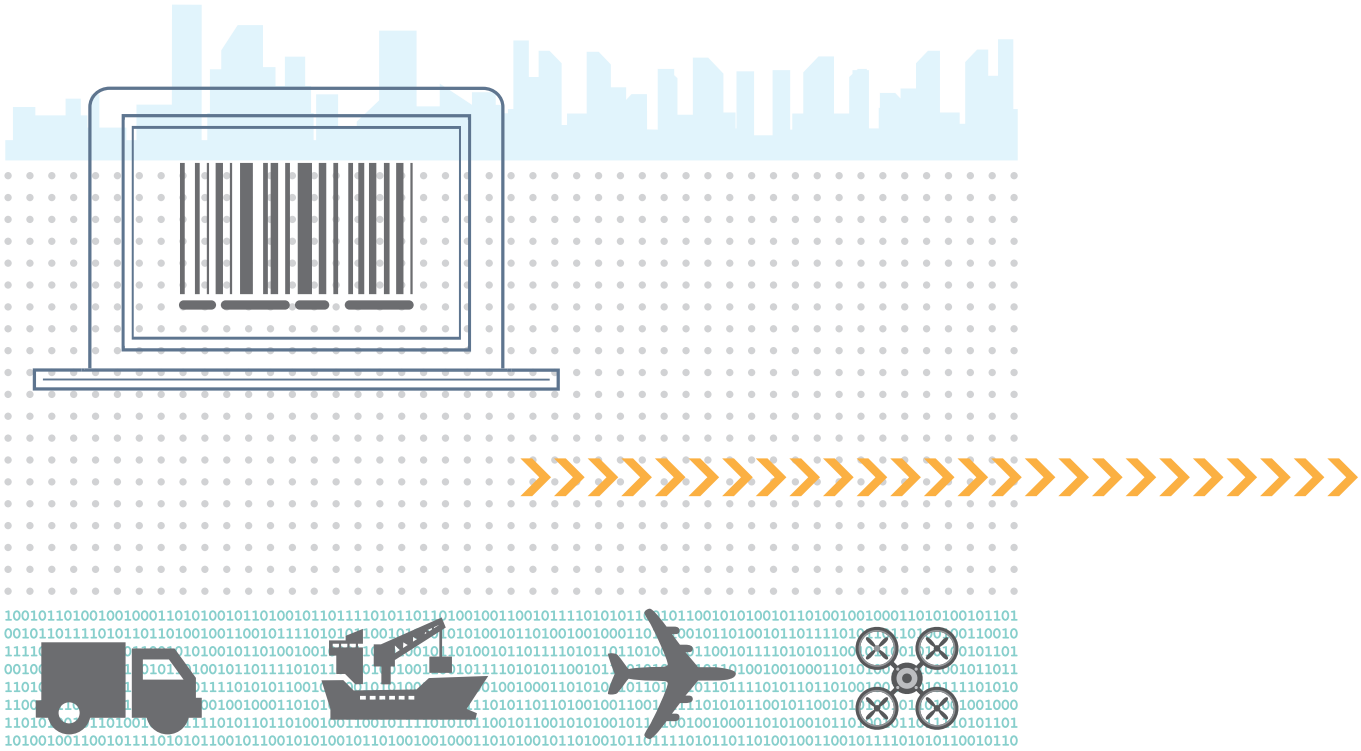
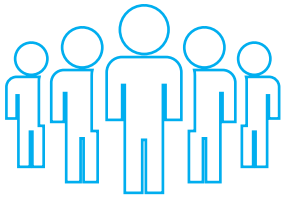


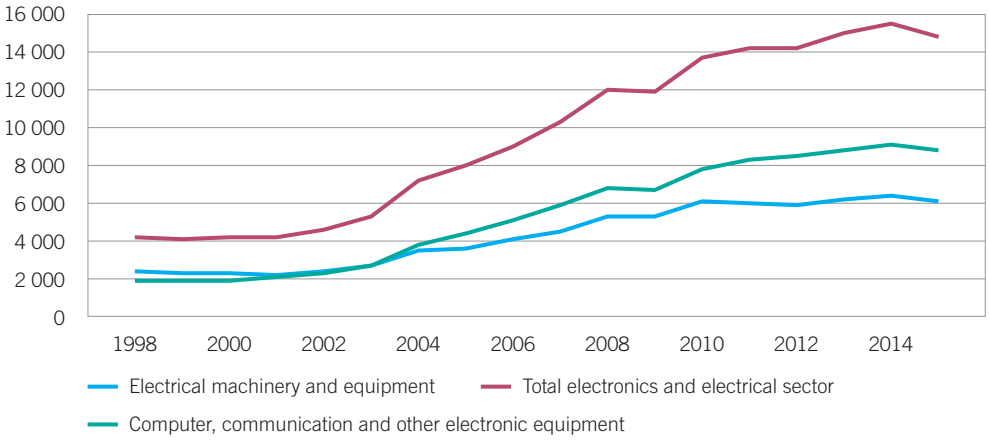
# APPENDIX A The impact of technology in the E&E sector: A focus on China



## 1 Overview of electronics production in China

Employment in China's electronic industry has exhibited strong growth since 2002 (see figure 5). However, in 2015, the number of individuals employed dropped to 14.8 million individuals (from 15.4 million in 2014). While more longitudinal data is required to fully understand this trends, the reduction in numbers from 2014 could be due to a number of factors, such as the changing nature of manufacturing and new streamlined processes, efficiency developments and demographic changes. It also may have arrived as a result of the current economic slowdown in 2008, as well as the movement towards a more service-based economy.

**Figure 5 Employment in the E&E sector and sub-sectors (thousands), 1998–2015**



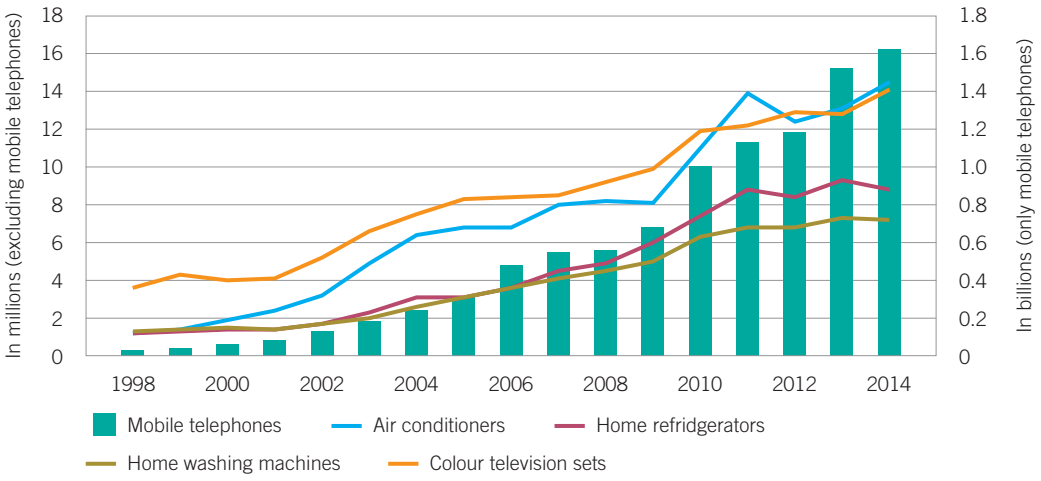

Note: Employment in the E&E sector and subsectors refers to the number of people employed in urban units.
Source: National Bureau of Statistics of China, 2016.

Given the potential high-tech, high-value nature of the electronics industry, it has become an area of targeted development by China and its government as it looks to move manufacturing up the value chain. It aims to transition away from the environmentally and socially damaging production techniques to the higher end of the market, where products with high value are produced at unrivalled quality and speed (see figure 6).

From white goods to consumer electronics, production increases and market growth over the past 20 years have helped China establish itself as the largest, most developed production ecosystem in the world. In 2014, the electronics sector contained 14,034 industrial enterprises that produced over 1.6 billion mobile phones and exported computer equipment to the value of US$160 equipment to 202 different countries worldwide.[41]

[41] National Bureau of Statistics of China, 2016; UN Comtrade, 2016. Industrial enterprises are defined by the National Bureau of Statistics of China as enterprises for the manufacture of computers, communication and other electrical equipment.

**Figure 6** **Total production of selected electronic goods in China, air conditioners, home refrigerators, home washing machines, colour television sets (million units), mobile telephones (billion units), 1998–2014**




Note: Primary y-axis includes the production of air conditioners, home refrigerators, home washing machines, colour television sets (expressed in million units); secondary y-axis includes the production of mobile telephones (expressed in billion units).

Source: National Bureau of Statistics of China, 2016.

Specific categories of electronics have differing regional production clusters. In the global E&E landscape, China produces large numbers of component parts, 3C goods and white goods (e.g., washing machines and refrigerators).

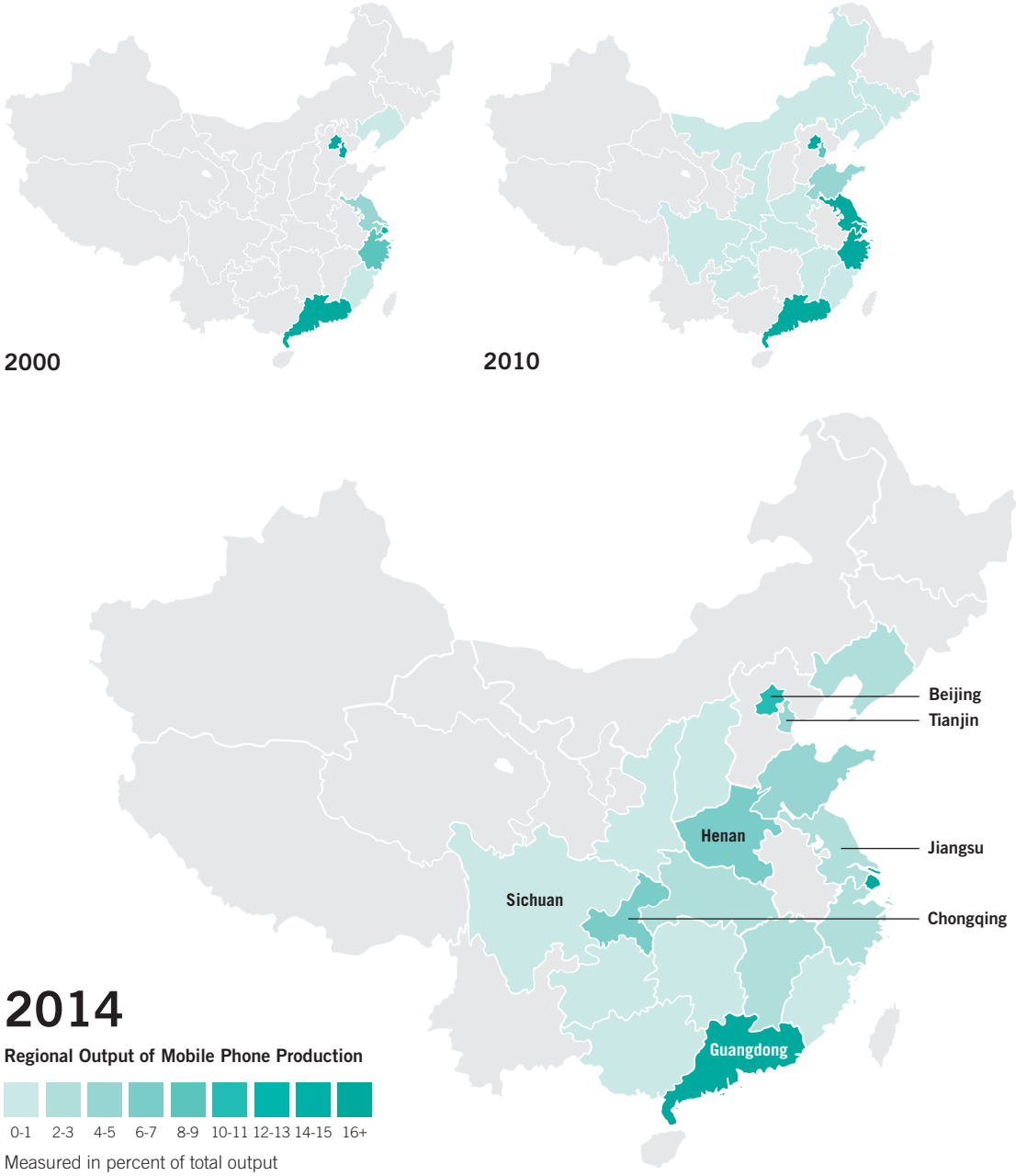
### 3C – Mobile phone production

Since 2000, China's regional mobile phone production has changed considerably, with new locations emerging as major manufacturing hubs and China's domestic mobile phone market serving more and more domestic consumers. At this time, the eastern regions of Beijing, Tianjin and Guangdong were the top producers. Now, as the domestic market has grown and taken hold, production has become more distributed throughout the country. Movement to the inner provinces has been stark, and largely been in search of the cheaper, more available labour of the central regions. However, Guangdong still remains a top mobile phone manufacturing hub. In 2014, of the 1.6 billion mobile phone units produced in China, 49 per cent were produced in Guangdong province. Within this province lies Shenzhen, which has long been a major Chinese innovation centre.

One clear contrast between 2010 and 2014 is the emergence of Henan as the third largest mobile producer, increasing output from 22,000 to 120 million units during this time period. This can, almost solely, be attributed to the construction of the Foxconn factory in Zhengzhou, which employs 300,000 people with an estimated output of 200,000 mobile phones per day. Foxconn is the well-known manufacturer of the Apple iPhone, and Henan is China's most populous Chinese province with the country's lowest wages. This move provides evidence of the continued importance of low-cost, abundant labour for even the higher value goods. In contrast, output in Beijing over the same time period has reduced 34 per cent, largely due to the rising cost of manufacturing and Beijing's transition to the services sector and its high levels of FDIs in services industries.

Other regional examples in the sector include the vast relocation of microcomputer equipment from the provinces of Jiangsu and Shanghai to Chongqing and Sichuan. From 2010 to 2014, the Yangtze River Delta region reduced its production contribution from 76.3 per cent to 37.1 per cent while Chongqing and Sichuan went from 0.8 per cent to 40.1 per cent. The opening of Tianfu Software Park in 2005 facilitated this relocation. In 2009, Intel optimized its global manufacturing resources by relocating its assembly and testing factory in Shanghai to Chengdu.

**Figure 7 Regional production of mobile phones (percentage of total), 2000–2014**



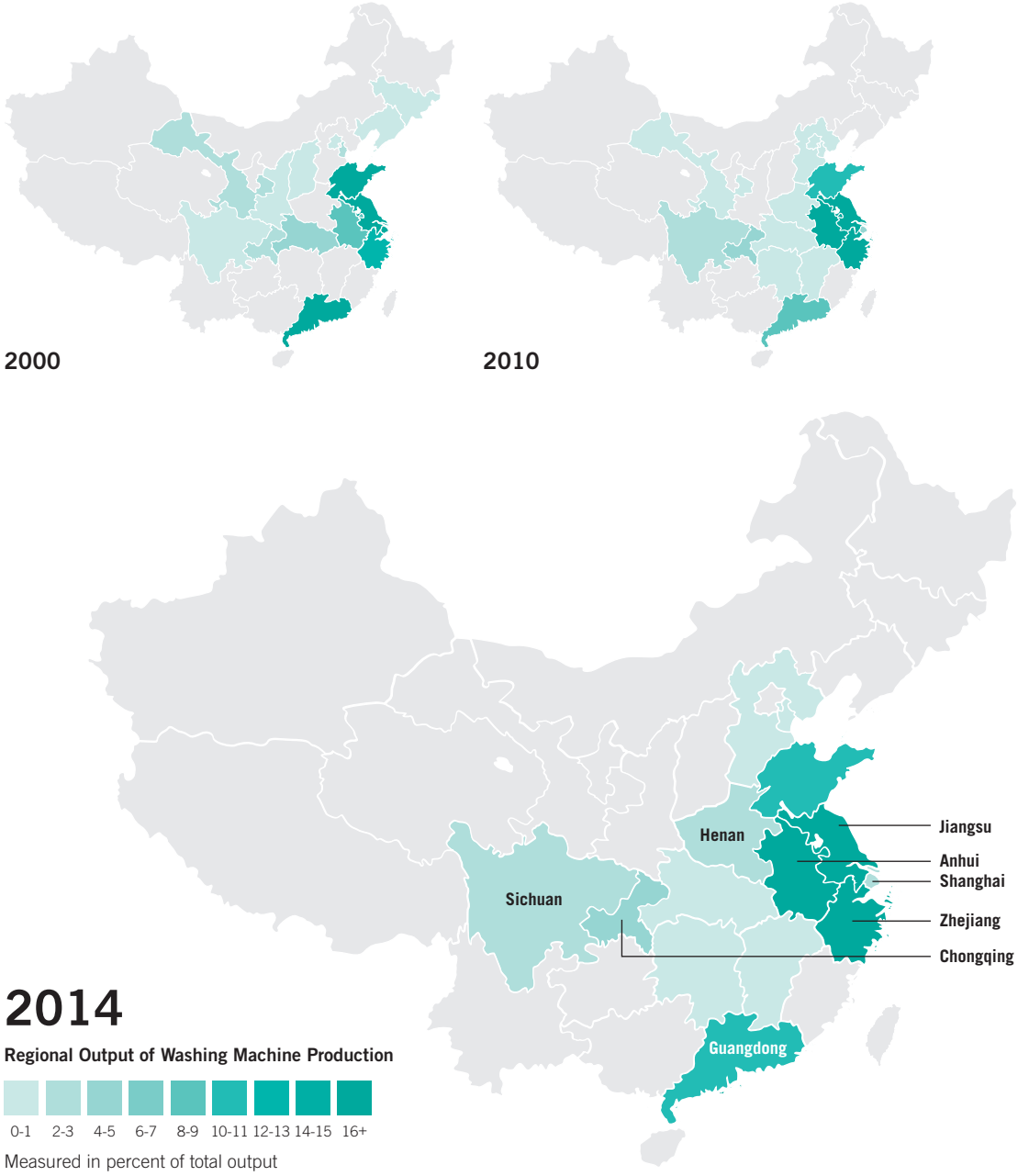

Source: National Bureau of Statistics of China, 2016.

**White goods – Washing machine production**

The manufacturing cluster for white goods primarily lies in and around the Yangtze River Delta. In 2014, the majority of China's 71 million washing machines were produced in the provinces of Zhejiang, Jiangsu and Anhui, accounting for over 65 per cent of the country's output.

Over the last 15 years, production has become more widely distributed throughout the provinces. Guangdong's contribution has experienced a reduction as the 3C industries developed with the worldwide boom of mobile smart phones and portable computers. Production now exists in more provinces than ever, and the central regions of Sichuan, Henan and Chongqing have increased their contribution to output from 2.8 per cent to 8.7 per cent, providing evidence of production movement to central provinces.

**Figure 8 Regional production of washing machines (percentage of total), 2000–2014**




Source: National Bureau of Statistics of China, 2016.

The E&E's movement into the central regions of China have resulted due to many large-scale decisions, such as government incentives to stimulate employment and GDP growth, as well as the presence of lower cost labour. Although production in the more economically prosperous eastern regions remains, their total contributions have been diminished (with the exception of Guangdong's dominance in 3C manufacturing).

## 2 Trends, movements and analysis of the ASEAN and Chinese systems

In this section, the changing nature of China and ASEAN electronics manufacturing is addressed, highlighting the advantages and disadvantages of both regions. Discussed are the industrial decisions being made to help reduce cost and increase quality through automation uptake, specific relocation and streamlined production.

### 2.1 GENERAL TRENDS

**Movement up the value chain**

China is transitioning its manufacturing up the value chain, moving from contract manufacturers fulfilling orders for Western brands to product development that can compete in the market. This transition is supported by the Government through its "Made in China 2025" initiative, which outlines targets to increase quality and encourage automation with incentives at the national and provincial levels. For example, at the provincial level, Guangdong is offering up to a 20 per cent subsidy for purchases of locally manufactured robotics products, whilst providing additional funding to local R&D.[42]

**Movement is occurring for some actors, but the industry is difficult to relocate**

Electronic investments and factory set-up involve a considerable amount of initial capital. This makes the industry more difficult to relocate than other sectors, such as textile cut-and-sew operations. Factories contain large amounts of expensive equipment that cannot be easily relocated to other territories. Therefore, relocation requires this equipment be sold, moved or disposed. Although movement from China to ASEAN (and India) are occurring, these decisions are usually very measured, made when commitments to operations are longer term to achieve desired ROIs.

**China is still the leader, and will remain so for a long time**

Despite movements and statements of intent to relocate production from a number of brands and manufacturers, the majority of interviewees choose China as the number one location for electronics production, both currently and for the next ten years. China's ecosystem of material supply, component supply, labour and production is so advanced and mature that little rivals it but labour cost. This is highlighted by the high percentage of Apple Inc. manufacturing locations, with 44 per cent of its global manufacturing supply coming from China, which represents 78 per cent of Asian production.[43] China also has a large number of smaller scale manufacturers that can produce a wide range of products and services.

42 Matsuda, 2015.

43 Apple, 2016.

## 2.2 CHINA'S ADVANTAGES

**Material supply chain**

China has a vast and expansive material supply chain. China not only possesses large quantities of raw materials, but also boasts a large supply of component parts. In fact, sourcing for many consumer goods is possible within a singular province, such as Guangdong and Shenzhen.

**Skilled labour**

For assembling electronic products efficiently, a productive and an experienced labour force is a key aspect to product development. Chinese workers have an experience and work productivity that results in high quality and fast outputs. This is one side of the labour pool. The other comprises of an increasingly educated labour force that can operate and run machinery. Indeed, China has observed an expansion in its educated labour pool, with 5.11 million undergraduates enrolled in engineering courses in 2014 (up from 2.77 million in 2005).[44] As manufacturing moves towards Industry 4.0, the supply of engineering graduates will form an important part of successful technology implementation.

**Infrastructure**

China's infrastructure is as established as many of those in the developed world. In terms of port capacity, it has some of the largest. China's port capacity is far superior to that of ASEAN. In 2013, China's ports could serve 174 million units. Comparatively, Viet Nam's port capacity was 8 million. Myanmar and Cambodia are essentially landlocked.[45] Moreover, China's roads are well connected and its trains are fast, with established networks and consistent links available. In fact, China can now transport goods over ground to very distant locations – even Europe. China's electricity grid supply is also very advanced when compared to other ASEAN countries, where electric blackouts are known to occur.

**Power of the domestic market**

The electronics market in China is the largest in the world. As a result, enterprises with large market shares, or the will to develop a large market share, will have a strong Chinese manufacturing base. On the other hand, if there is a lack of Chinese consumer interest and markets are focused predominantly in Europe, the United States, and emerging economies, then the viability of production in China diminishes.

**Trusted system**

Many foreign MNEs have close relationships with manufacturers in China and understand the system. Chinese pricing is considered competitive. Chinese workers output is well known to be consistent and efficient. Despite lower labour costs outside of China, relocating manufacturing outside of China can come with reduced labour productivity, inefficient infrastructure and supply issues.

44 National Bureau of Statistics of China, 2016.

45 ASEAN countries lack basic infrastructural needs within the delivery of supply. The condition of roads is poor and ports have significantly lower capacity.

## 2.3 ASEAN'S ADVANTAGE

**Cost reductions**

Potential cost reductions throughout the business structure make ASEAN a compelling region for relocation for Chinese manufacturers. This is true not just for labour, but also land, energy, water and waste management processes. Relocation to ASEAN is especially possible and accessible for products without end-to-end supply in China (for products with an end-to-end supply in China, relocating is more complex). Although manufacturing in China is advantageous currently, relocating outside of China may occur if production costs continue to increase and alternative production methods are not sought to maintain competitiveness.

**Young and educated labour pool**

Compared to China's rapidly aging population, ASEAN has an abundant and young labour pool. In particular, Viet Nam's workforce is particularly attractive. Its population is increasingly better educated as a result of the Government's high spending on education. Almost 21 per cent of government expenditure was spent on education in 2010, a larger portion than that seen in any Organisation for Economic Co-operation and Development (OECD) country.[46] Moreover, in global rankings published by the OECD in 2015 on mathematics and science, the Programme for International Student Assessment, Viet Nam ranked twelfth in the world (Singapore ranked first).[47]

**China imposing stricter regulations**

More recently, China has begun to strengthen its regulations in relation to compliance, safety and environmental degradation. This means that previously acceptable operations have come under greater scrutiny, which has forced closures or relocations. This impacts the costs associated with operating factories, as higher levels of regulations result in increased monetary investment to comply with legislation. These increased costs can tip the balance for some actors.

**Chosen areas of relocation**

While China has a substantial and wide ranging ecosystem for the development of electronics, there has been movement for some enterprises and areas of supply.

**A move to central and west**

Relocation within China not only resulted because of lower wages in other regions, but also to attract a labour force that is less willing relocate to the eastern provinces for work. For many, factories closer to home are preferable. Examples of enterprises that have moved production to central China are Foxconn, Schneider and Intel. Governments in these provinces also offer vast loans and incentives to set up factories in these regions. These inland factories have a higher proportion of assembly. Incentivizing their construction also reduces political and economic friction because job creation and GDP growth can result without introducing job losses in places like Shenzhen.

46 Schleicher, 2015.

47 OECD, 2015.

> "They [the government] practically give away factories, if the companies can employ a large number of the local population."
>
> Founder, Electronics Sourcing Company, Shenzhen and Southern China, ILO interview, 2016.

**Thailand and Viet Nam are the most compelling new locations**

Currently, Thailand and Viet Nam are the primary destinations for China's relocation efforts. However, these relocations are mostly executed by bigger enterprises, as they have the capital to do this. Viet Nam's high profile construction of several Samsung factories reflects this. Similarly, Sony has announced that it plans to establish manufacturing operations in Thailand as part of its mobile industry redevelopment efforts. As a result, Thailand could become a stronger high-end E&E hub.

There is talk of future, smaller scale movement occurring. Recent economic factors can accelerate the shift. India has potential for a scalable market, as well as a large pool of engineering talent. However, it is understood that there is reluctance from Chinese players to invest in these regions; they prefer to have operations domestically, or, at the very least, move to South-East Asia where they have access to Chinese speaking workers.

## 3 Key findings

**The economic situation in China could have a potential impact**

The current economic downturn in China is discouraging E&E players to invest in the country itself. This may have a negative impact on foreign enterprises that are normally the first to innovate product development and production techniques.

**Automation great in theory, the practicalities can be a different story**

Many enterprises in China see automation as the solution to maintaining, or increasing, factory production. However, it is not as simple as it sounds. Implementing automation involves many other organizational improvements and changes in factory culture – something difficult to achieve in China. This is not to say investments will not occur, but rather, efforts to automate E&E manufacturing will be measured and carefully considered.

**Robot sales are rising**

In 2014, robotics sales to China totalled 57,096 units, a 56 per cent increase from the previous year.[48] This demonstrates the industry's commitment to roboticized operations and marks the beginning effects of government policies that increase worker-to-robot ratio. Most recently, in 2016, Foxconn confirmed this trend, as it replaced 60,000 workers with robots, also called "Foxbots", in one of its Kunshan factories near Shanghai.

48 IFR, 2015.

**Where robotics are used, they are predominantly German and Japanese, but Chinese R&D is increasing**

Despite intent from the China's Government to increase the market of local players to 50 per cent by 2020, the majority of robotics sales in China come from the big four German and Japanese robotic producers – ABB, Fanuc, Yaskawa and Kuka; these four accounted for 65 per cent of China's robotic purchases in 2013.[49] A representative of ABB noted that real competition from Chinese suppliers of industrial robots is not expected for ten to 15 years. The major reason for this delay lies in the lack of key component technologies: controllers, server drives and precision gearboxes. These are vital to the usability and complexity of robotics. Currently, the German and Japanese systems are superior. Furthermore, the "Made in China 2025" initiative highlights this as a vital and requisite area of development. However, to speak to China's competitive potential, reports increasingly show that China is emerging as an R&D hub. In 2015, one research company revealed that China has caught up with the United States in attracting FDI in R&D efforts. In fact, China's second-most active R&D areas lie in business machines and equipment and consumer electronics.[50]

**Product complexity and level of automation are inversely correlated**

Assembling complex products have lower potential levels of automation. Therefore, more manual labour is required. 3C products, of which China produces 70 per cent of the world's supply, are the most complex of E&E goods, and their assembly is almost all done by hand. White goods and large electrical goods, such as TVs, have lower complexity and larger parts. As a result, their assembly process can be more automated.

**Short product lifetimes are a barrier to automation**

Because E&E companies release new products frequently, the short product lifetime (and therefore short production run) impedes investment in automation. The equipment is relatively inflexible and difficult to adapt to new products. This may change in the future as robots become more intelligent, but at the moment, humans are better at adapting to new production techniques. Investment in automation is economically viable, for example in the automotive industry, where long runs and high investment cost justify full automation development.

**The Chinese domestic market is key to domestic production**

The Chinese domestic market for electronics is the largest in the world. If manufacturing is moved overseas, then products could be subject to import duties and increase pricing. While the China-ASEAN free trade agreement should limit this impact, "no free trade agreement is free". There exists a myriad of requirements for product certification under these legislations. For those looking to capitalize on the domestic market and increase market share, keeping production within China is a must.

**Only the biggest players can relocate and automate with ease**

Currently, only large-scale moves by large E&E players, such Samsung's expansion into Viet Nam, are feasible. These relocations pose the most hope for growing ASEAN's E&E production. When Foxconn moved to Henan, or Samsung to Viet Nam, these companies took all operations with them and imported the materials required. Smaller E&E players are unable to do this. Therefore, in the short to medium term, relocation is likely to be reserved only for the biggest industrial players.

49 Research in China, 2014.

50 Fingar, 2015.

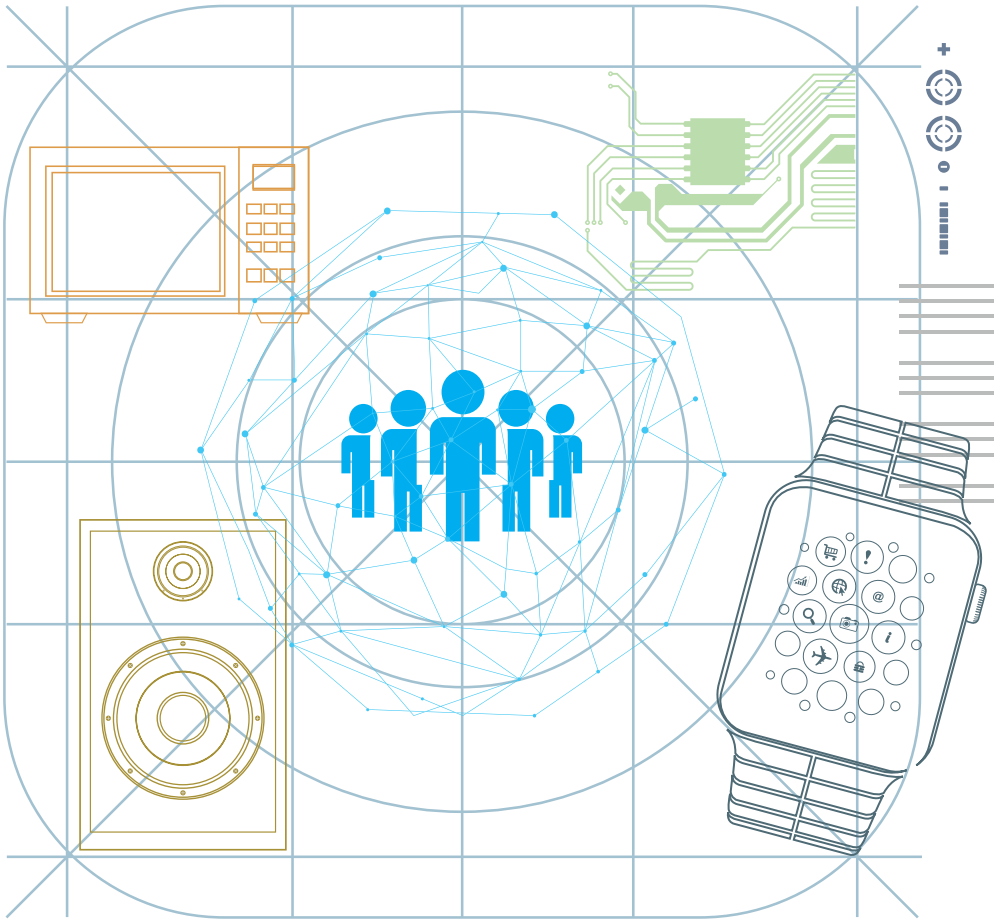
Similarly, when these factories are set up, a higher degree of automation is likely to be incorporated. In these scenarios, the factories start with a clean slate and therefore can adopt the latest technology, if economically viable, as opposed to working within the restrictions of current factory operations or displacing large portions of a workforce. The high runs that large companies have also makes automation investment more compelling because their ROI is more likely.

**Reshoring is not a trend**

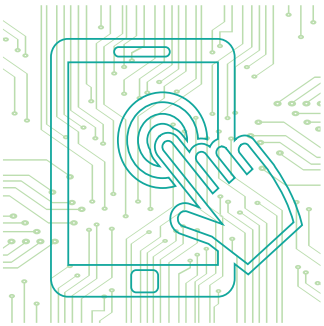
Interviewees mentioned that moving E&E manufacturing back to Europe and the United States is unlikely. For Europe and the United States, it is currently not possible to achieve the same speeds of production as China, and the motivation behind reshoring mainly caters to poor consumer perceptions of goods "Made in China".

**Industry 4.0**

Industry 4.0 is the new era in manufacturing. It describes developed, highly intelligent, data-driven production lines and production systems. Automation and robotics represent only one part of this industrial development, and people throughout the industrialized world are developing such systems. China is certainly a player in the Industry 4.0 movement, and production efficiency conflicts with rising costs investing in Industry 4.0 systems are increasingly important considerations in how enterprises choose to move forward. While the uptake in China will not be as swift as in Europe, China will begin to incorporate these systems in its manufacturing sector within the near future.



# APPENDIX B E&E characteristics and trends per ASEAN country

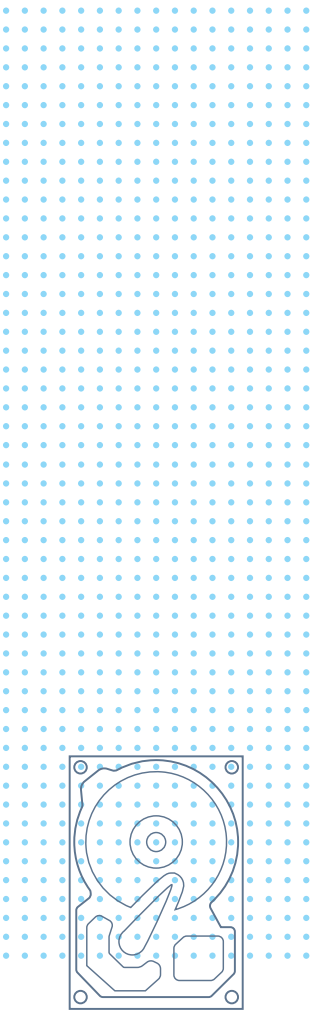


**Singapore** primarily produces electronics components (mainly semiconductors, silicon wafers, and hard-disk components) and is a leader in E&E services, particularly component design, supply-chain management[51] and regional distribution.[52]

**Malaysia**'s E&E sector is a key contributor to its GDP, employment and trade.[53] The sector actively manufactures electrical components and electronic parts – primarily semiconductors, microchips, conductors and valves – as well as household appliances, radio equipment, solar cells and solar power systems.[54] However, over the last five to 15 years, Malaysia has increased its focuses and energies into R&D for its E&E sector, continuing its strong R&D start in the 1990s among semiconductors firms, and there has not been much investment and growth in its E&E manufacturing. Although, Malaysia has seen an expansion in assembling low value added PCBs and flexible PCBs using large numbers of less skilled foreign workers.[55]

The E&E sector in Malaysia is focused on deepening and strengthening its three major product ecosystems for semiconductors, solar and light-emitting diode (LED) technologies. Semiconductors are especially expected to continue spearheading growth. Malaysia's semiconductors industry will benefit from growing global demand for mobile devices, smartphones, tablets, storage devices (such as cloud computing, data centres, personal data drives), optoelectronics (photonics, fibre optics, LEDs) and embedded technology (ICs, PCBs, LEDs). While the sector has shown appetite for technology and innovation, the country still lacks the adequate pool of skilled talent for high value added activities such as component manufacturing or R&D.[56]

**Thailand** is the world's second biggest manufacturer[57] of hard-disk drives, supplying about 30 per cent of the global market.[58] Thailand is a significant regional producer of PCBs and microchips. MNEs including Fujitsu, LG Electronics, Samsung, Seagate, Sony and Western Digital all have significant activities in Thailand.[59] Thailand is also reportedly the world's second largest manufacturer of air conditioning units and a significant producer of refrigerators. Multinational companies including Bosch, Daikin, Electrolux, LG, Panasonic, Samsung, Siemens and Toshiba all play an active role.[60]



51 Key manufacturers in Singapore include Broadcom Corporation, Infineon Technologies, Seagate Technology, and STMicroelectronics among others (Singapore Electronic Development Board, 2016). Some of Singapore's foremost electronics manufacturing services providers include Asustek, Celestica, Flextronics, Jabil Circuit, Lite-On, Sanmina, Venture, and Wistron, among others (ibid).

52 McKinsey and Company, 2014.

53 MITI, 2016.

54 MATRADE, 2016.

55 ILO interviews conducted with the Malaysian Investment Development Authority (MIDA).

56 Ibid.

57 China comes top with about 35 per cent of the market.

58 Kasikorn Research Centre, 2015.

59 Ibid.

60 Thailand Board of Investment, 2015a.

In recent years, Thailand struggled to find a foothold in the global supply chain of modern technology like smartphones and tablet computers. The country's manufacturing index has been stuck in the doldrums, with production of goods like televisions and radios significantly dropping. Thailand's innovation ranking in the World Economic Forum's Global Competitiveness Index fell from 36 in 2006 to 54 in 2014.[61] The decline is raising concerns that Thailand's economic slowdown is not a temporary problem caused by its political malaise but a structural one caused by the manufacturing industry's failure to adapt and the increasing attractiveness of its lower-cost neighbours.[62]

**The Philippines** E&E industry contributes 14 per cent to the country's GDP and accounts for more than 50 per cent of total exports.[63] ICs remain the most traded products, followed by semiconductor devices and PCBs. In 2015, China and Japan together accounted for more than 40 per cent of the Philippines' overall PCBs and semiconductor devices exports. As the country focuses more on IC design activities, jobs in the designing sector are expected to boost in the coming years.[64]

**Viet Nam**'s E&E sector has become a very strong regional presence over the past five years or so.[65] Multinational manufacturers including Intel, Microsoft, LG and Samsung have all recently created a presence in Viet Nam. These companies have mainly shifted away from China and other higher cost locations.[66] Electronics exports expanded by 76 per cent between 2010 and 2014, reaching US$38 billion in 2014.[67] In 2015, the top three items (ICs, semiconductor devices and PCBs) recorded export revenues of US$5.9 billion against US$5.1 billion in 2014.

Much of this growth was driven by investments from handsets and phone parts manufacturing, which accounted for 59.4 per cent of total electronics exports in 2013.[68] Multinational companies like Samsung Electronics produce 50 per cent of their mobile phones in Viet Nam, and in late 2015, Samsung[69] won government approval to invest an additional US$2 billion in Viet Nam.[70] These developments have contributed to the growth of the Vietnamese manufacturing ecosystem.

61 WEF, 2006; WEF, 2014.

62 Sriring and Temphairojana, 2015.

63 Oxford Business Group, 2016; UNCTAD, 2016.

64 Initiatives such as the Product and Technology Holistic Strategy (PATHS) proposed by the Semiconductor and Electronics Industries in the Philippines Foundation, Inc. (SEMI) aims at determining global technology and industry trends in the E&E space and identifying the products that the Philippines industry can focus on. Overall, the project aims at investment promotion, improve infrastructure, skills and policy which are required to boost the industry over the years to come.

65 One news report says the sector accounted for 23.4 per cent of the GDP in Viet Nam in 2014, rising from only 5.2 per cent in 2010 (Tuoi Tre News, 2015).

66 Greene, 2014.

67 UNCTAD, 2016.

68 BDG Asia, 2014.

69 Samsung makes 50 per cent of its mobile phones (240 million units) in Vietnam (Jin-young, 2015).

70 Nguyen, 2015; Jin-young, 2015.

Moving forward, Viet Nam's E&E sector also expects continued growth; however, enterprises should capitalize on a few opportunities. Electronics and telecommunications manufacturing are at the forefront of Viet Nam's master plan for industrial development leading up to 2025. This industrial development plan features E&E, industrial processing and sustainable energy as sector priorities.[71] Although, despite Viet Nam's high export growth rates, the electronics industry has seen low added value because most materials have been imported. To help ensure continued growth, areas in which Viet Nam's E&E players could look into include: procuring and exporting goods to other countries (for larger and perhaps medium-sized Vietnamese E&E enterprises) and manufacturing E&E goods for domestic E&E players (this would be a good strategy for smaller, Vietnamese E&E enterprises). Indeed, our interviews with domestic electronic firms confirm these strategies would be fruitful for Viet Nam's E&E enterprises. What the country's sector cannot accomplish, at the moment, is exporting and producing for MNEs, as Viet Nam's E&E sector does not possess the technological capabilities to meet the quality and quantity of the orders expected from MNEs.[72]

Moreover, Viet Nam's E&E players have also met tough competition from foreign-owned companies based in Viet Nam. For example, Samsung announced that they have 90 component suppliers operating in Viet Nam, a very large amount. In fact, Vietnamese-owned E&E firms only accounted for 10 per cent of total E&E suppliers in the country, which illustrates how prevalent foreign-owned operations are. Overall, domestically owned suppliers in Viet Nam have primarily provided low value-added services like packing and printing.[73]

In **Indonesia**, three products (ICs, semiconductor devices and PCBs) recorded export revenues of US$1.08 billion in 2015. Batam, the major E&E hub for Indonesia, is heavily populated with subsidiaries of Singapore-based MNEs. The main composition of the E&E industry in Batam, Indonesia, includes consumer electronics, audio and video equipment, electronic components for automobiles, PCBs, and other components and parts (cables and wires, among others). Overall, Indonesia struggles as an E&E favoured destination for E&E goods assembly. ASEAN rivals such as Viet Nam and even higher cost countries like Malaysia are more competitive destinations. Enterprises cite industrial relations issues (such as strikes and unpredictable increases in minimum wage) and weaker infrastructure (in terms of road quality and utilities like electricity provision) as reasons why other ASEAN countries are preferable for E&E production.

**Cambodia**'s E&E component exports surged in recent years. These components are mostly shipped to Thailand and signal the formation of a regional supply chain. From 2009 to 2014, Cambodian's E&E equipment exports proliferated exponentially, from less than US$4.5 million in 2009 to almost US$320 million in 2014.[74] Yet, total exports remain relatively low for the region, and more than half of those exports consist of low-end parts, such as insulated wire and fuses.

Most of these manufacturers are Japanese-owned and they are appearing in Cambodia's special economic zones, aiming to establish another hub in the regional supply chain. Over the past few years, a handful of Japanese manufacturers of metallic goods such as Nikko-Kinzoku, which produces heat-resistant steel baskets to transport and store auto-parts, have started production in Cambodia, including auto components and electronics.

71 Vietnam Chamber of Commerce and Industry 2014; Vietnam Plus, 2014.

72 ILO interviews conducted in 2015.

73 VIETRADE, 2015.

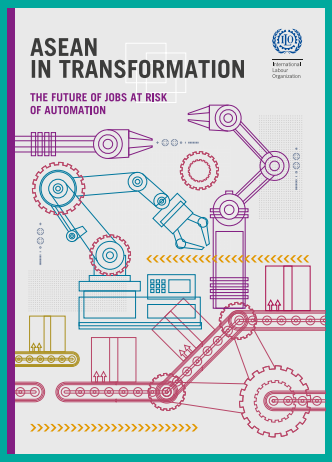
74 UNCTAD, 2016.

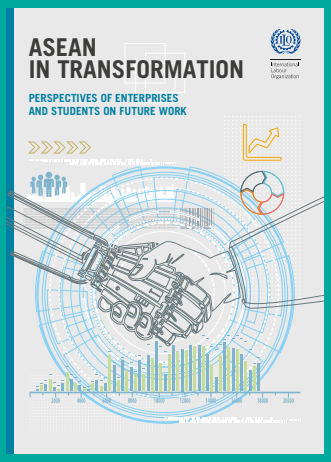
## ASEAN in transformation: Electrical and electronics - On and off the grid

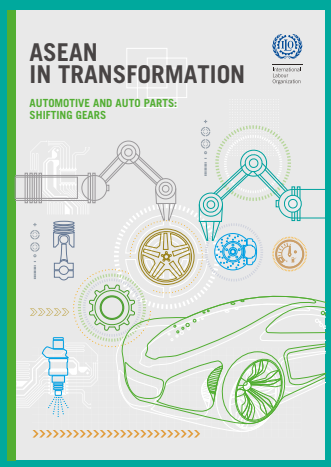
This paper examines the impact of technology and related implications for enterprises and their employment needs for the electrical and electronics sector in the ASEAN Member States. The main findings of this paper is available in *ASEAN in transformation: How technology is changing jobs and enterprises*, which offers a comprehensive compilation of transformative impacts of technological advancements penetrating five labour intensive and/or growth sectors in the ASEAN region.

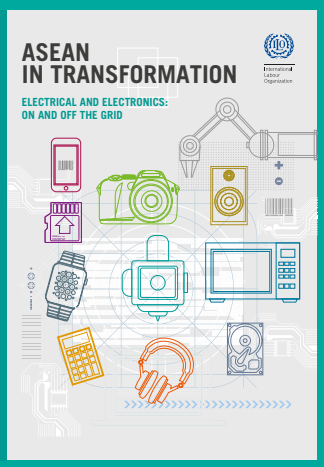
This paper highlights that ASEAN's electrical and electronics sector represents a key opportunity for the future of the region as it is becoming increasingly connected to every economic industry, directly or indirectly. Technologies such as the Internet of Things will push the sector to producing more innovative products and induce further growth and employment. In addition, production technologies such as additive manufacturing and robotics and automation are shifting the skills requirements of the sector.

While the industry overall is poised to grow, it needs more skilled workers. A targeted focus on education and skills policy in the region is necessary to help the sector progress up the value chain and to equip workers for the new job opportunities that arise from developments in the sector.



ACT/EMP
The Bureau for Employers' Activities

ISBN 978-92-2-131183-6

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