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ADAPTATION AND ADOPTION OF INDUSTRY 4.0 IN CAMBODIA

SCOPING REPORT

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Adaptation and Adoption of Industry 4.0 in Cambodia

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Contributors

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ACRONYMS

Acatech	(Germany) National Academy of Science and Engineering
ADB	Asian Development Bank
AI	Artificial intelligence
ASEAN	Association of Southeast Asian Nations
CBS	Cyber-physical systems
FDI	Foreign direct investments
GDP	Gross domestic product
GDI	General Department of Industry
ILO	International Labour Organization
IDP	Industrial Development Policy
ICT	Information and communication technology
ISC	Institute of Standards of Cambodia
IoT	Internet of things
JICA	Japan International Cooperation Agency
LDC	Least-developed country
LTA	Long-term agreement
ML	Machine learning
MOEYS	Ministry of Education, Youth and Sport
MIH	Ministry of Industry and Handicraft
MLTV	Ministry of Labour and Vocational Training
MOP	Ministry of Planning
MSMEs	Micro-, Small and Medium-sized Enterprises
OECD	Organisation for Economic Co-operation and Development
RGC	Royal Government of Cambodia
SMEs	Small and medium-sized enterprises
SEZ	Special Economic Zones
STEM	Science, technology, engineering and mathematics
SDGs	Sustainable Development Goals
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
TVET	Technical and Vocational Education and Training
WIPO	World Intellectual Property Organization

EXECUTIVE SUMMARY

Cambodia's 2030 and 2050 visions can only be realised by exploiting the potential of new technologies to upgrade and diversify its economy. Cambodia has made important progress: its economy has grown at rates above 7% since 2011, and the share of people living in poverty has more than halved in the last decade. The Royal Government of Cambodia's (RGC) Rectangular Strategy sets out the vision to become an upper-middle-income country by 2030 and a high-income country by 2050. As recognised in the Industrial Development Policy (IDP) 2015–2025, this vision can only be achieved if new technologies are leveraged to increase industrial value added, diversify exports and strengthen small and medium-sized enterprises (SMEs).

Cambodia's manufacturing has increased its contribution to the economy over the last couple of decades, mainly driven by the garment and food industries. The contribution of manufacturing to Cambodia's GDP has increased from below 10% in the 1990s to over 16% in 2018. It now provides 1.4 million jobs. However, Cambodia's manufacturing is concentrated in two main sectors: *textiles, clothing and footwear and food and beverages.* Together, they account for 80% of manufacturing value added and 76% of the country's exports.

Industry 4.0 has the potential to create new sources of value for workers, firms, sectors and countries. Industry 4.0 applications and solutions are becoming cheaper, more widely available and easier to use. There is broad international agreement that the use of these technologies has the potential to drive opportunities for more efficient and productive use of labour, capital and natural resources. Manufacturing firms can leverage Industry 4.0 to offer digitally enabled ("smart") products, services, supply chains and delivery. Industry 4.0 capabilities could also be extended from manufacturing to other sectors of the economy and society. According to some estimations, productivity increases from new technologies could have an economic impact of up to US$625 billion in the ASEAN region alone by 2030.

The term Industry 4.0 is often misunderstood and Cambodia still lacks a "champion". The term Industry 4.0 is not used consistently and is often used interchangeably with other labels such as "Fourth Industrial Revolution" and "digital economy". The lack of clarity regarding the scope of Industry 4.0 complicates communication and collaboration between stakeholders, and, so far, no "champion" has clearly emerged promoting its adoption in Cambodia.

It is generally agreed that Industry 4.0 refers to the widespread integration of information and communication technology (ICT) in manufacturing. In particular, Industry 4.0 is underpinned by engineering systems that link the "cyber" world (e.g. software, computational algorithms and wireless communication) with the "physical" world (e.g. machines and human users). As such, Industry 4.0 goes beyond the development of mobile phone apps and e-commerce platforms. Meanwhile, "Fourth Industrial Revolution" is associated with *a wider range of technologies* (including biotechnology, nanotechnology and new materials) and their application across *all sectors of the economy.* Finally, official definitions of "Digital Economy" typically define it as the *trade of goods and services through electronic commerce* – although some recent definitions used in Cambodia refer to the use of digital technologies in the overall economy.

This report focuses on the opportunities and challenges arising from Industry 4.0, and the policy options required to harness its potential in Cambodia. Conceived by the United Nations Development Programme (UNDP), this investigation aims to support ongoing efforts in Cambodia by more closely

investigating how the adaptation and adoption of Industry 4.0 technologies could help address constraints to sustainable industrial development in Cambodia. The investigation draws upon consultations with local public and private sector stakeholders, brings together both technological and economic perspectives, and reviews the latest academic and policy evidence on the topic of Industry 4.0.

Both "optimistic" and "pessimistic" views on the implications of Industry 4.0 for developing countries are found in the international debate. In order to gain a balanced view, the report reviews the international development and academic literature across themes, including: impact on jobs; the role of manufacturing as a driver of economic growth; inequality between developed and developing countries; market concentration; and gender inequality. The emerging picture is one characterised by contrasting views but also one that highlights the need for countries to act.

Cambodia has the opportunity to build on a number of conditions to support the adaption and adoption of new technologies, including Industry 4.0. Cambodia has a growing economy with increasing FDI flows and a demographic dividend of young people. A number of initiatives are being put into place to promote technology and innovation in the country, including a strategic framework for Cambodia's digital economy. Opportunities exist to exploit technological spillovers from FDI, to leverage the participation in global value chains, and to further develop established international economic partnerships.

Private sector stakeholders perceive that Industry 4.0 represents an opportunity to boost productivity, reduce costs and diversify the economy. Specific opportunity areas from Industry 4.0, identified by the local stakeholders consulted, include: energy management; predictive maintenance; traceability; inventory and distribution management services; increasing value-added from food processing; the creation of more sophisticated tasks and better-paid jobs; and integration into regional supply chains.

The level of Industry 4.0 adoption in Cambodia is still low, as is the case in many developing and developed countries. The stakeholders consulted suggested that digital technology in the majority of firms (over 90%) is still at a basic level. At firm level, barriers to adopting Industry 4.0 in Cambodia include: a lack of awareness of digital technologies and their benefits; the perceived high costs of technologies; an aversion to the use of new

technologies; skills gaps; limited access to training and technical assistance; and constrained access to finance. Low levels of Industry 4.0 adoption are also reported by recent surveys in both developing (including ASEAN and Latin American countries) and developed countries (including European countries).

Efforts are required to raise awareness of Industry 4.0 technologies and their benefits; to make these technologies more widely accessible; and to develop the skills needed to use them. The consultations carried out suggest that these efforts will be required in parallel with initiatives – some of which are already in progress – to develop the enablers that underpin Cambodia's competitiveness as an industrial location. These contextual enablers include: investments in basic and digital infrastructure; improvements in the institutional framework; addressing financial constraints; and strengthening linkages between innovation actors.

The evidence base around Industry 4.0 in Cambodia needs to be further strengthened with in-depth sector-specific analysis and firm-level insights. This scoping report generated significant cross-sectoral insights into Cambodia's readiness to adapt and adopt Industry 4.0 technologies. While there is broad consensus about the potential large-scale impact of Industry 4.0, there is a need to strengthen the evidence base about the particular opportunities and challenges for Cambodia by conducting sector- and firm-level analyses in the next stages of the project.

Practical mechanisms for the roll-out of Industry 4.0 in Cambodia need to be identified. Based on the mapping of existing institutions and ongoing initiatives in the country, it is suggested that appropriate mechanisms for the roll-out of Industry 4.0 need to be identified. Such mechanisms could take different forms: centres of excellence, competence centres, technology institutes and innovation networks. Their potential implementation in Cambodia should be informed by international best practice. Whatever the institutional form, Industry 4.0 roll-out requires activities to address barriers across three key areas: *technology transfer and deployment; technology awareness and diffusion; and technology development and importing.*

National roadmaps can bring local stakeholders together to co-develop options, identify key actions and agree on steps for implementation. Roadmaps could help to develop an Industry 4.0 strategy that addresses the particular challenges facing firms in Cambodia, complementing wider efforts to reap the benefits of digital technologies. Co-development by local stakeholders is essential to ensure that activities are grounded in the realities of the country, reflect on past experiences and promote ownership.

In the months since this report was compiled Cambodia, like other nations, has been impacted by the Covid pandemic. The implications of this for Industry 4.0 are picked up in a separate Covid Update that follows. The pandemic makes the transfer of these technologies and know-how still more prescient for Cambodia - enabling reopening and repurposing of the industrial sector, better management of uncertainty and delivering new productive capacities through digitalization.

COVID-19 UPDATE

COVID-19 INCREASES IMPORTANCE OF DIGITAL TRANSFORMATION FOR CAMBODIA

Across the world, the COVID-19 pandemic is driving profound changes in the way we communicate, work and live. On the industrial front, firms are facing **supply and demand disruptions** today and an uncertain global landscape in the future.

As we move forward, emerging evidence suggests that **digital technologies will play a crucial role in addressing these challenges.**

This report explores how digital technologies can be leveraged to support sustainable industrial development in Cambodia, based on higher value added and economic diversification, as envisioned by the Royal Government of Cambodia's Rectangular Strategy.

In particular, the report focuses on the **opportunities and challenges driven by Industry 4.0 – the widespread integration of digital technologies across manufacturing products, processes and operations.**[I] Initial consultations with stakeholders in Cambodia have already identified opportunities in several areas, including: energy management, predictive maintenance, traceability, inventory, and distribution management services.

The COVID-19 pandemic is accelerating a number of digitalization trends. In doing so, it is revealing more opportunities for Cambodia's industrial upgrading and diversification.

Opportunities range from the increasing use of digital payments; brick-and-mortar shops using online sales channels for the first time; new digital business models; use of responsive supply chain management systems to address supply disruptions and uncertainty in demand; and access to remote technical assistance and training as a response to travel and social distancing restrictions.

Responding to Cambodia's challenges through innovation

Cambodia has successfully contained the spread of the pandemic, with only 141 cases confirmed and zero deaths as of 1 July.[II] However, the global economic effects of the pandemic meant that Cambodia's industries experienced a "double hit".

The first was the **"supply hit"** felt in Cambodia even before the disease arrived in the country. As early as February, garment factories were already reporting shortages of supplies, primarily due to the closure of factories in China. Some Cambodian manufacturers decided to suspend operations.

There was then a more significant **"demand hit"** as orders from clients in Europe and the United States dried up. Within manufacturing, the garment industry is the most affected by demand shocks in Cambodia.[III] Hundreds of garment firms have suspended operations due to reductions in orders.[IV]

The speed and quality of the industrial recovery will depend on a number of international factors but also on the strategies implemented by firms, development actors, and the Royal Government of Cambodia. Governments and firms around the world are seizing the COVID-19 crisis as an opportunity to upgrade technology, diversify and improve environmental sustainability.

I Section 1 of the report defines Industry 4.0 and its interfaces with similar concepts, such as Fourth Industrial Revolution and Digital Economy.

II Johns Hopkins (2020). *COVID-19 Dashboard.* Center for Systems Science and Engineering (CSSSE).

III UNIDO (2020). *Impacts of COVID-19 on the Private Sector. Survey report.* Cambodia.

IV Interview with representatives of the Garment Manufacturers Association in Cambodia (GMAC).

As has happened in previous crisis, emerging evidence suggests that more innovative firms tend to be more resilient to shocks. Firms are now leveraging digital technologies to address the challenges posed by the COVID-19 pandemic.

Specific examples of applications in manufacturing, the focus of the report, include:

- ***Repurposing production capacity.*** Dozens of garment firms in Cambodia have repurposed to produce personal protective equipment (PPE). Digital technologies can help firms to adapt production processes to those goods in high demand. Applications include designing and modelling of modifications of production lines, 3D printing for rapid prototyping, and rapid digital design for injection moulding.

- ***Managing uncertainty in supply chains.*** Disruptions in supply chains and volatility in demand require responsive planning models to help decision making. Data analytics and machine learning applications can help build prediction models and respond to real-time changes across the supply chain.

- ***Accessing data, expertise and training remotely.*** Travel and social distancing restrictions have meant higher reliance on remote data and expertise. Cloud-based systems can facilitate accessing operational and management data remotely; while augmented and mixed reality (AR/MR) solutions can help accessing technical support and training.

- ***Enabling digital orders and customer support.*** In times of travel restrictions, methods of fulfilling customer orders must change. Digital applications can help firms sell products and services through online shops, update clients on inventory levels, provide virtual product presentations and training, and offer remote customer support and after-sales services.[v]

Although the adoption of these applications has been mainly triggered as a response to short- to medium-term disruptions, these adoptions are likely to have long-lasting effects in firms' capabilities as a result of the skills and capacity developed.

Key takeaways in this report

As discussed in this report, the adoption of digital technologies in Cambodian industries requires a number of contextual enablers, including: **further investments in basic and digital infrastructure; skills development; and improvements to the institutional framework.**

It also requires **deliberate efforts to help Cambodian firms to adopt and adapt these technologies,** with specific support policies that draw from international experience but are driven by local needs.

In developing these pre-conditions, **Cambodia would strengthen its competitive advantages and be better prepared to seize the opportunities from the imminent reconfiguration of supply chains in the ASEAN region.**

V Industrie 4.0 Maturity Center (2020). *Industrie 4.0 & Covid-19. How to deal with digitalization strategies during the crisis?*

INTRODUCTION

Industry 4.0 occupies a central role in the industrial and innovation strategies of both developed and developing economies. Cambodia is no exception: the Royal Government of Cambodia has placed Industry 4.0 at the heart of the fourth iteration of the Rectangular Strategy, its national medium-term development strategy, and activities in this area have been initiated across various ministries. This study was conceived by the United Nations Development Programme (UNDP) to contribute to ongoing efforts by more closely investigating the opportunities and challenges arising from Industry 4.0, and also the policy options required to harness its potential in Cambodia.

Industry 4.0 is widely recognised as having great potential to enable innovative applications and to impact global manufacturing-based industries. New possibilities enabled by Industry 4.0 include step changes in production efficiency, the large-scale production of custom-made products with minimal use of time and resources, and the creation of new markets based on digitally enabled products and related services.

In Cambodia there is particular interest in the potential effect of Industry 4.0 on the country's competitiveness as an industrial location. On the one hand, key areas of concern include the potential impacts of Industry 4.0 on the country's cost advantages, diversification prospects and employment. On the other hand, questions exist regarding the industrial opportunities that might be unlocked through the adoption of Industry 4.0. This includes opportunities for accelerating development through technological and industrial "leapfrogging".

At the most basic level, Industry 4.0 describes the widespread integration of information and communication technology (ICT) in industrial manufacturing.[1] However, the term has not been used consistently in policy studies and practice. A number of related terms and initiatives such as the "Fourth Industrial Revolution", "Next Production Revolution" and "digital economy" are often used interchangeably with Industry 4.0 without clarity of definitions. Confusion regarding the scope and boundaries of Industry 4.0 arises because of the pervasive nature of ICT, which has applications across multiple sectors and economic activities.

As a result, studies aimed at estimating the impact of Industry 4.0 on national economies, utilising diverse methodologies, are based on different assumptions and produce widely diverse results. In practice the lack of clarity about what Industry 4.0 is (and what it is not) has caused confusion regarding the policy areas that are relevant to Industry 4.0 and how they relate to one another.

Because the scope of this project is Industry 4.0, the investigation presented here focuses on opportunities, challenges and policy responses for manufacturing industries. However, in developing country contexts, such as Cambodia, there is great interest in approaching the role and significance of Industry 4.0 through a wider agenda of economic development. In view of this, efforts are made to compile evidence on the potential impact of Industry 4.0-related technologies on other sectors of the economy and on selected development themes.

1 Acatech (2017). *Industrie 4.0 Maturity Index*. Germany's National Academy of Science and Engineering.

In terms of *opportunities*, a primary task is to build the evidence base around the potential for Industry 4.0 to enable both sectoral upgrading (increasing the value-added in established industries) and diversification (moving into new high-value-adding economic activities) through the development of digital capabilities in Cambodia.

In terms of *challenges*, relevant issues include potential information gaps (including levels of awareness), capability gaps (including firm-level barriers to technology transfer and innovation) and gaps in the national innovation system and the basic infrastructure.

In terms of *policy options*, the main focus of this project is on technology *diffusion* and *deployment* rather than new technology *development.* International evidence suggests that, besides top-performing companies, developing economies such as Cambodia host large groups of businesses operating below the frontier of innovation, using basic technologies and constrained by skills gaps. There is therefore an opportunity to support industrial upgrading and diversification through the adoption of technologies that are becoming not only more widely available in the market but also cheaper, easier to use and more widely tried and tested.

Naturally, the analysis described above needs to account for ongoing national efforts and the characteristics of national institutions. Similarly, the project has recognised from the outset the need to integrate multiple sources of evidence and stakeholders' perspectives. Technology analyses need to be complemented with assessments of the country's industrial composition and areas of value-chain specialisation. Evidence from local industry, government, academia and civil society needs to be elicited and cross-examined in a structured manner.

Recognising the diversity of views around the subject of technological change in general, and Industry 4.0 in particular, efforts are made to synthesise key perspectives emerging from studies, positioning papers and research projects produced by international development agencies, national governments and academia. "Optimistic" and "pessimistic" perspectives are contrasted, and the evidence on which such views are based is analysed.

This report summarises the findings of the first stage of a Long-Term Agreement (LTA) with UNDP, aimed at providing a secure foundation of knowledge in relation to the overall goals of the study. A key output of this stage is a better definition of particular areas of focus for the next stages of the project, in order to ensure that the work programme is as useful as possible to inform the policy agenda of the Royal Government of Cambodia (RGC), as well as UNDP's programmatic support on the topic of Industry 4.0.

The remainder of the report is structured as follows:

- Section 1 provides a definition of Industry 4.0, discusses its interfaces with related terms and conceptualises the opportunities and barriers for value capture enabled by it.
- Section 2 reviews the international evidence on the opportunities and challenges arising from Industry 4.0 for developing countries and discusses the contrasting views found in the literature.
- Section 3 describes Cambodia's economic and industrial context and discusses how Industry 4.0 might be relevant for the country's socio-economic development agenda.
- Section 4 presents indicators of Cambodia's "readiness" for the adaptation and adoption of Industry 4.0 and draws upon stakeholder consultations to provide an initial assessment of the main barriers to the adaptation and adoption of Industry 4.0 in Cambodia.
- Section 5 discusses emerging policy themes to support the roll-out of Industry 4.0 in Cambodia, in the context of the national policy agenda.

In addition:

- Annex 1 presents an outline roadmap for the roll-out of Industry 4.0 in Cambodia.
- Annex 2 identifies priority themes for the next stages of the LTA and suggests programming recommendations for UNDP.
- Annexes 3, 4 and 5 present lists of the stakeholders consulted.

SECTION 1
WHAT IS INDUSTRY 4.0?

Key points of this section

- Industry 4.0 describes the widespread integration of information and communication technology (ICT), particularly cyber-physical systems (CPS), in industrial manufacturing.
- The term Industry 4.0 has not been used consistently, because of the diversity of trends, technologies and applications associated with it.
- While the scope of Industry 4.0 is *industrial manufacturing*, the term "Fourth Industrial Revolution" is associated with *a wider range of technologies* (including biotechnology, nanotechnology and new materials) and their application *across all sectors of the economy.* Meanwhile, "Digital Economy" primarily refers to the *trade of goods and services through electronic commerce.*
- The use of sound definitions is necessary to appropriately identify policy areas that are relevant to support the adaptation and adoption of Industry 4.0 and to enable communication and collaboration between the relevant stakeholders.

1.1 Introduction

Technology adaptation and adoption are widely regarded as drivers of industrial and economic progress. These processes have underpinned the catch-up experience of countries such as Japan, Germany, South Korea and Singapore.[2] In particular, this project focuses on the opportunities and challenges arising from the adaptation and adoption of "Industry 4.0", and the policy responses for addressing them.

The term Industry 4.0, or "Industrie 4.0", was introduced in 2011 as part of the German government's High-Tech Strategy. Since then, Industry 4.0 has emerged as one of the most important themes in the national industrial and innovation agendas of both developing and developed countries. The term, however, has not been used consistently, because of the diversity of trends, technologies and applications associated with it. The boundaries of Industry 4.0, and its interfaces with concepts such as "Fourth Industrial Revolution" and "Digital Economy", are not well understood. This has important implications for policy design, as the lack of clarity in definitions results in uncertainty regarding the subject of investigation and the relevant policy areas.

2 Reda, C. and Hasanov, F. (2019). *The Return of the Policy That Shall Not Be Named: Principles of Industrial Policy.* IMF Working Paper No. 19/74. International Monetary Fund. Washington, DC.

To contextualise this investigation, this section discusses the concept of Industry 4.0, including common definitions and associated technology trends. The section also introduces relevant frameworks to characterise the value capture opportunities arising from Industry 4.0; and it describes the "digitalisation journey" that firms need to undergo in order to exploit these opportunities.

1.2 Industry 4.0 – a working definition

Industry 4.0 refers to the widespread integration of information and communication technology (ICT), particularly cyber-physical systems, in industrial manufacturing. Cyber-physical systems use sensors, actuators, control processing units and communication devices to link the "cyber" world (e.g. software, computational algorithms and wireless communication) with the "physical" world (e.g. machines and human users).

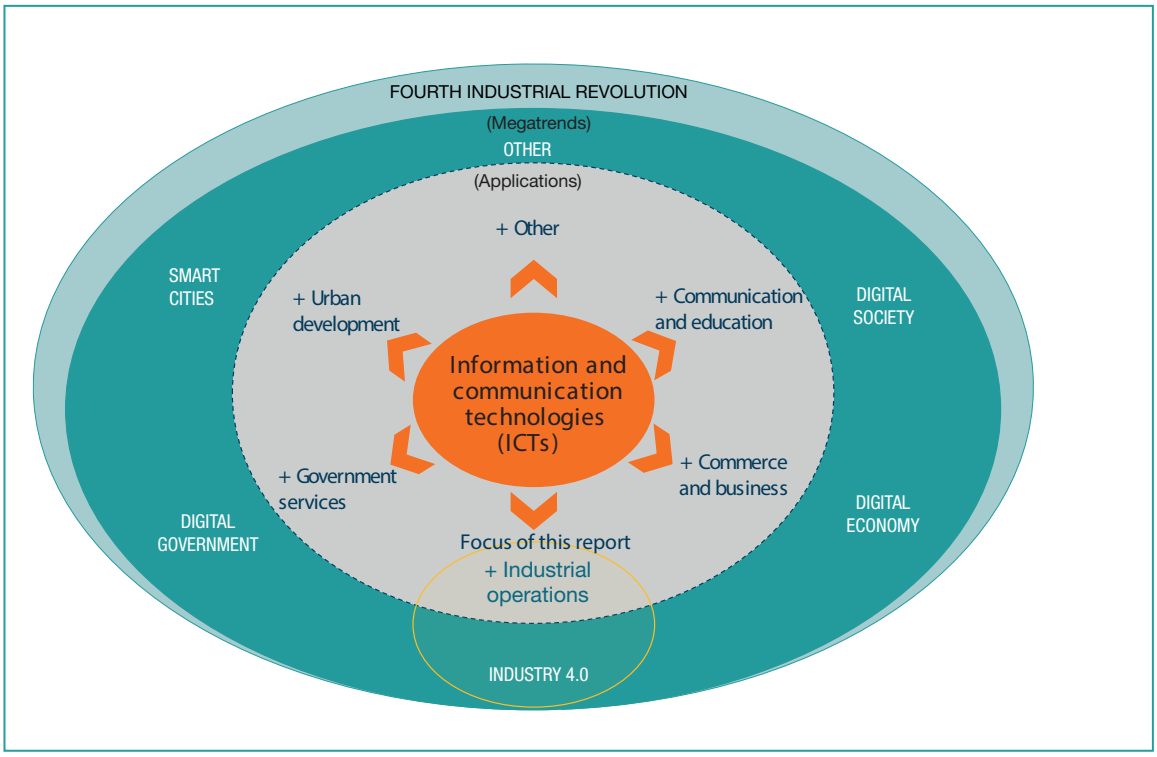
In short, Industry 4.0 refers to the widespread integration of information and communication technology (ICT), particularly cyber-physical systems (or CPS), in industrial manufacturing.[3] Cyber-physical systems are engineering systems that link the "cyber" world (e.g. software, computational algorithms and wireless communication) with the "physical" world (e.g. machines and human users). These systems comprise a set of networked agents, including: sensors, actuators, control processing units and communication devices.

Because cyber-physical systems generate data that enables "smarter" analysis and decision-making, they constitute the basic principle behind a wide range of so-called "smart" applications that go beyond manufacturing. Cyber-physical system applications used in energy distribution are often labelled "smart grids", applications in transportation are often called "smart mobility" and those in health care are often known as "smart health" – and so on.

More generally, the application of digital technologies across the whole economy has given rise to terms such as "smart cities", "digital government", "digital economy" and "digital society", and the "Fourth Industrial Revolution". Figure 1.1 provides a simplified illustration of the interfaces between these terms, and Table 1.1 lists some of the most widely used definitions.

3 Acatech (2017). *Industrie 4.0 Maturity Index*. German National Academy of Science and Engineering.

Figure 1.1 Interfaces between Industry 4.0 and related terms



Source: Policy Links (2019).

As is clear in Table 1.1 (below), there is no single "official" definition of Industry 4.0. The international organisations, governments and think tanks of different countries use a range of definitions, some narrow and some broad. Terms often used interchangeably with Industry 4.0 include: "smart manufacturing", "digital manufacturing", "industrial Internet", "smart factories", "cloud manufacturing", "cyber-physical production systems", "advanced manufacturing" and "Fourth Industrial Revolution". These terms do not necessarily have one-to-one correspondence and they are not necessarily defined or used consistently.

Beyond Germany, the terms "smart production", "smart manufacturing", "smart factory" and "industrial digitalisation" are often used in Europe, in the US the term "advanced manufacturing" is more commonly found in official government publications, while in China national initiatives tend to refer to "intelligent manufacturing".

The definitions presented in Table 1.1 help to clarify the differences between Industry 4.0 and other labels used to describe technological megatrends, including "Fourth Industrial Revolution" and "Digital Economy". While the scope of Industry 4.0 is industrial manufacturing, the term "Fourth Industrial Revolution" is associated with a wider range of technologies (including biotechnology, nanotechnology and new materials) and their application across all sectors of the economy. Meanwhile, "Digital Economy" primarily refers to the trade of goods and services through electronic commerce.

Table 1.1 Digital technology megatrends – selected definitions

INDUSTRY 4.0	
Technology focus: - Cyber-physical systems (CPS), which include sensors, actuators, control processing units and communication devices - Internet of things (IoT) - Advanced production technologies (e.g. 3D printing) **Sector focus:** - Industrial manufacturing	Industrie 4.0 is focused on creating smart products, procedures and processes. Smart factories constitute a key feature of Industrie 4.0. Acatech (2013). German National Academy of Science and Engineering. The term Industry 4.0 has been used since 2011 to describe the widespread integration of information and communication technology in industrial manufacturing. Acatech (2017). German National Academy of Science and Engineering. Industry 4.0 stands for the implementation of digital technologies into industrial production systems and the increasing automation and connectivity in manufacturing. OECD (2019). The Digital Innovation Policy Landscape in 2019.
FOURTH INDUSTRIAL REVOLUTION	
Technology focus: - ICTs - Advanced materials - Photonics - Biotechnology - Microtechnology - Environmental and energy technologies **Sector focus:** - All sectors	The "Fourth Industrial Revolution", or the "Next Production Revolution", entails a confluence of technologies ranging from a variety of digital technologies (e.g. 3D printing, Internet of things, advanced robotics), to new materials (e.g. bio- or nano-based) and new processes (e.g. data-driven production, artificial intelligence, synthetic biology). As these technologies have an impact on the production and distribution of goods and services in practically all sectors, they are expected to have far-reaching consequences for productivity, skills, income distribution, well-being and the environment. OECD (2017). The Next Production Revolution: Implications for Governments and Businesses
DIGITAL SOCIETY	
Technology focus: - Internet - Big data - Social media - Mobile networks **Sector focus:** - Media and communications - Education	We are living in a digital society, in which every aspect of our lives is being profoundly affected by the digitalisation of data: how we communicate and socialise; and how we work, learn, stay healthy and participate in politics and the economy. Digital Society Programme (2018). Dutch Association of Universities

DIGITAL ECONOMY	
Technology focus: - Internet - Digital trading platforms - Mobile networks - Big data - Artificial intelligence - Machine learning **Sector focus:** - Narrow: digital services and platform economy - Broad: overall economy	The digital economy comprises markets based on digital technologies that facilitate the trade of goods and services through electronic commerce. OECD (2012). The Digital Economy. "Digital products and services are facilitating more rapid change across a wider range of sectors rather than being confined to those high-technology sectors that had been the main focus previously [...] This is especially relevant for developing countries where the digital economy has begun to affect the traditional sectors, such as agriculture, tourism and transportation." UNCTAD (2019). The Digital Economy Report.
SMART CITIES	
Technology focus: - Internet of things (IoT) - Big data - Digital trading platforms - Social media - Mobile networks **Sector focus:** - Energy services and utilities - Transport services - Construction and infrastructure	A smart city is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services, such as energy, transportation and utilities, in order to reduce resource consumption, wastage and overall costs. The overarching aim of a smart city is to enhance the quality of living for its citizens through smart technology. Techopedia (2019). Smart City Definition. A smart city is "one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources". IBM (2011). Smart Cities series: Introducing the IBM city operations and management solutions.
DIGITAL GOVERNMENT	
Technology focus: - Internet - Mobile networks - Digital trading platforms - Social media **Sector focus:** - Government	The OECD defines digital government as "the use of digital technologies, as an integrated part of governments' modernisation strategies, to create public value", which "relies on a digital government ecosystem comprising government actors, non-governmental organisations, businesses, citizens' associations and individuals, which supports the production of, and access to, data, services and content through interactions with the government." e-Government refers to "the use by the governments of information and communication technologies (ICTs), and particularly the Internet, as a tool to achieve better government". OECD (2014). Recommendation of the Council on Digital Government Strategies.

Source: Policy Links (2019).

1.3 Industry 4.0 – common elements

Despite semantic variations, a number of common and related elements can be identified in definitions of "Industry 4.0". The first one refers to the use in manufacturing of a range of digital applications and solutions, based on a wider family of technologies related to cyber-physical systems, including (see Table 1.2 for further details):

- The Internet of things (IoT);
- Cloud computing;
- Big data;
- Machine learning (ML);
- Artificial intelligence (AI);
- Advanced production technologies such as 3D printing and hybrid production systems.

Another common element is the increased *connectivity* of manufacturing-based industrial systems (achieved through the application of the Industry 4.0 family of technologies listed above), enabled by:

- Improved sensing/interacting with the physical world;
- Enhanced organisation/sharing/analysis of data;
- Better networking/control of different elements and activities across industrial systems.

A further element found in Industry 4.0 definitions concerns *improvements in productivity and competitiveness* through, for example:

- Greater product personalisation (the production of small series and customised products) through highly reconfigurable production systems;
- Greater production throughput through increased automation and reduction of defects and downtimes;
- Improved energy and resource efficiency through better process monitoring and control;
- Shorter product-development lead times through to stronger links between design and production;
- Production localisation through, for example, distributed 3D-printing facilities.

Finally, a common element is the diversity of *new opportunities for value capture* enabled by Industry 4.0 for firms, sectors and countries (described in Section 2):

- Opportunities for firms;
- Opportunities for sectors;
- Opportunities for countries;
- Opportunities for workers;
- Opportunities for global grand challenges.

Table 1.2 Key technologies underpinning Industry 4.0

Cyber-physical systems (CPS)	- Systems formed of electronic hardware (including **sensors and actuators**) and software (including **computer interfaces and control algorithms**) designed to **sense and interact** with the physical world (including human users). - By providing a rich variety of real-time data from production processes, cyber-physical systems can be used to improve the **adaptability, flexibility** and **customisation** of manufacturing operations.
Internet of things (IoT)	- The Internet of things refers to **networks of physical objects** (devices, vehicles, buildings, equipment, etc.) **connected to the Internet**. - In the IoT, cyber-physical systems generate and capture data from the physical world and transmit it through the network infrastructure for it to be analysed and employed by distinct applications.
Big data	- The large-scale deployment of cyber-physical systems, together with improvements in industrial networking, have led to the **exponential growth of data volume and traffic**. - These **large data sets**, whose size is beyond the capability of typical database software tools to capture, store and analyse, are commonly known as "big data".

Cloud computing	On-demand network access to a **shared pool of computing resources** (e.g. networks, servers, storage, applications and services).
Blockchain	System for recording and sharing encrypted data across multiple data stores.
Machine learning (ML)	Machine learning is considered an enabler of artificial intelligence. In its most basic form, machine learning refers to the **use of algorithms to analyse data, learn from it and then make decisions about specific tasks**. Rather than writing a specific set of software code to instruct a machine to do a particular job, machine-learning algorithms give it the ability to learn how to perform a task by **training the system using large amounts of data or big data**.
Artificial intelligence (AI)	Artificial intelligence refers to the **use of data to take decisions or perform certain tasks that are normally considered to require human knowledge, intelligence, learning and understanding**. Such tasks include: visual perception, speech recognition and decision-making.
Advanced production technologies, including 3D printing and hybrid production systems	3D printing encompasses multiple techniques used to build solid parts by adding material in layers. This stands in contrast to typical manufacturing processes in which material is removed or formed. While 3D printing has been in use since the mid-1980s, recent advances in accuracy and repeatability are broadening its potential application areas. Hybrid production systems combine various types of technology (e.g. machining, cutting and laser-based heat treatment) within single machines, thereby eliminating steps, reducing changeover times and potentially shortening the supply chain.
Other	Other technologies typically described under the umbrella of Industry 4.0 include advanced robotics and automation technologies; virtual reality (VR); and augmented reality (AR).

Source: Adapted from UNIDO and Policy Links (2017). *Emerging trends in global advanced manufacturing: challenges, opportunities and policy responses*. Report for the United Nations Industrial Development Organisation, Vienna.

1.4 New sources of value enabled by Industry 4.0

There is broad consensus internationally about the potential large-scale impact of Industry 4.0 technologies in global industries. A number of academic, industry and government reports from around the world have provided visions of how the implementation of Industry 4.0 may create new sources of value in the short, medium and long terms.

There is broad consensus internationally about the potential large-scale impact of Industry 4.0 in global manufacturing. A number of academic, industry and government reports from around the world have provided visions of how the implementation of Industry 4.0 may create new sources of business value in the short, medium and long terms. An often-cited figure about the impact of Industry 4.0 is that this trend could create US$100 trillion of value for the global industry and society over the next decade.[4]

For firms, at least four main sources of value capture opportunities originate from Industry 4.0:

4 World Economic Forum (2016a). *Digital Transformation of Industries: Societal Impacts.*

- **Adoption of Industry 4.0 systems:** There is potential for user industries adopting Industry 4.0 to capture value from greater efficiency, flexibility, speed/responsiveness, precision and customisation. The flexibility to adapt manufacturing systems enabled by Industry 4.0 can allow firms to respond flexibly to disruptions in demand and supply. Industry 4.0 can enable the production of a custom-made product at mass production prices through the minimal use of time and resources. By generating data on the status of operations across the whole manufacturing process, Industry 4.0 allows managers to dramatically improve decision-making.

- **Manufacturing of key technology elements for Industry 4.0:** There is great potential for some firms to make a significant amount of revenue through the provision of key technology elements (embedded systems, robots, etc.).

- **Knowledge management and analysis:** There is also significant potential to capture value from selling tools or services enabled via the Internet of things.

- **Building the infrastructure:** Some firms will capture significant value from growing markets providing the sensors, batteries, broadband infrastructure and other technologies that underpin the expanding Internet of things.

From a **sectoral** perspective, Industry 4.0 is expected to drive new sources of value capture enabled by disruptions across four advanced manufacturing perspectives:[5]

- **"Smart products" (and services):** New products with improved functionalities, performance and reliability are being made possible through the use of digital technologies. Such products can also enable the provision of new services and the adoption of new business models.

- **"Smart processes" (and factories):** Industry 4.0 technologies can help make production processes and factories more automated, capable of achieving more complex shapes and tighter tolerances, and able to deliver individualised products at mass production prices.

- **"Smart supply chains"** (and supply-chain innovation): Digital technologies can make supply chains better integrated and more transparent. This includes the ability to source and supply raw materials and components more efficiently, and to establish supply chains for new products more rapidly.

- **"Smart delivery"** (and demand forecast): Digital technologies can enable superior levels of customer satisfaction. This includes creating stronger (digital) links between design, production and delivery, and more intensive use of big data analytics to better foresee the changing patterns of customer needs.

For **countries**, the impact will depend on each country's unique mix of industrial activities and areas of specialisation. New opportunities for value capture include:

- Increasing the competitiveness of **established sectors** by applying Industry 4.0 applications and solutions.

- Leveraging Industry 4.0 competencies to **diversify into new sectors and economic activities.**

- New digitally enabled products allow novel business models that reduce barriers to entry **for start-ups and small businesses** by giving them the opportunity to develop and provide downstream services. There are particularly significant opportunities for SMEs and start-ups to develop B2B (business-to-business) services for Industry 4.0.

- Industry 4.0 can help to tackle some of the challenges facing countries around the world, such as **resource and energy efficiency, urban production and demographic change.** Industry 4.0 enables continuous resource and energy efficiency gains across entire industries. Cleaner factories can be located closer to, or alongside, urban areas. Digitally enabled assistance systems are creating new opportunities for young and older workers (see below).

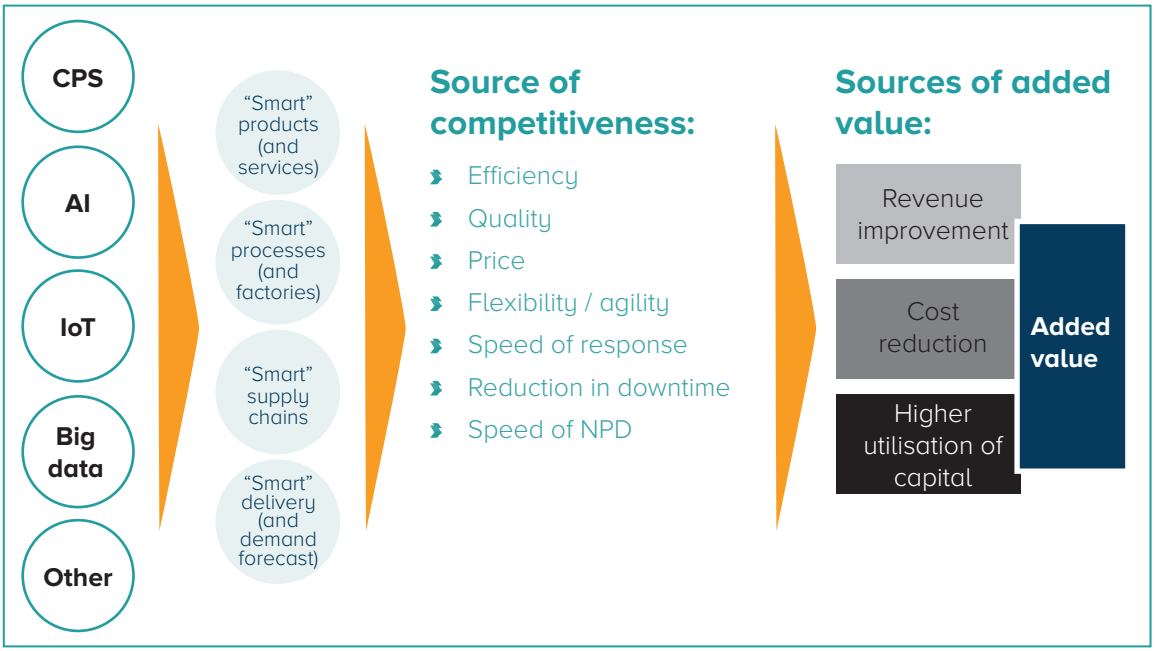
5 UNIDO and Policy Links (2017). *Emerging trends in global advanced manufacturing: challenges, opportunities and policy responses.* Report by the Institute for Manufacturing's Policy Links Unit, University of Cambridge, for the United Nations Industrial Development Organisation, Vienna.

For **workers,** Industry 4.0 can provide a number of benefits, including the following:[6]

- Flexible work organisation can help workers to combine work, private lives and continuing professional development more effectively, enabling a better work–life balance.
- Smart assistance systems can release workers from routine tasks, enabling them to focus on creative, value-added activities. They can also help older workers extend their working lives and remain productive for longer.
- Cleaner and more sophisticated manufacturing processes can be much safer and more professionally rewarding.

Figure 1.2 presents a simple diagram that illustrates how Industry 4.0 technologies can come together to foster competitiveness and enable value capture across some of the dimensions outlined above.

Figure 1.2 Sources of competitiveness and value capture through Industry 4.0



Source: Policy Links (2019).

1.5 Characterising barriers to value capture

While many Industry 4.0 applications and solutions are becoming cheaper, more widely available and easier to use, multiple barriers hinder the adoption and effective use of Industry 4.0 in practice. These include barriers to *developing, diffusing and deploying* technologies and know-how. Characterising the barriers of firms according to their place in the "Industry 4.0 journey" can help to inform policy design.

The major benefits of new digital technologies can only fully materialise when they are diffused and applied across firms, sectors and countries. While many Industry 4.0 applications and solutions are becoming cheaper, more widely available and easier to use, firms face a number of barriers to adapt and adopt them within their operations. Multiple barriers hinder the adoption and effective use of not only cutting-edge but also current best-practice technologies and methods.

6 Acatech (2013). *Recommendations for implementing the strategic initiative Industrie 4.0.* German National Academy of Science and Engineering.

Borrowing from the field of national innovation systems (NIS), [7] barriers to value capture can be classified into three broad categories:

- **Barriers to *developing* new technologies:** These are barriers to developing new technologies and advancing current technological know-how. They include: underinvestment in R&D; uncertainty of applications; and the disconnection between industry and academia.
- **Barriers to *diffusing* new technologies:** These are barriers to diffusing new technological know-how among actors of the national innovation system. They include: a lack of information-sharing among industry users; a lack of standards; and infrastructure gaps.
- **Barriers to *deploying* new technologies:** These are barriers faced by firms in the deployment of new available technologies in their operations. They include: low "absorptive capacity" to understand or use technology, especially among SMEs; difficulties upgrading legacy systems; and a lack of skills in firms.

These barriers affect different types of firm in different ways. Besides top-performing companies, emerging economies such as Cambodia host large groups of businesses operating far below the frontier of innovation, using basic technologies and constrained by skills gaps. In order to better understand the diversity of barriers hindering technology adoption (and to inform policy design), it is convenient to characterise firms according to their position in the "Industry 4.0 journey", as illustrated in Table 1.3.

This journey can be understood as a gradual build-up of managerial, technical and innovation capabilities. Firms first need to understand the business value of new digital technologies and later to identify opportunity areas for adoption. A key success factor in this process is the ability of firms to acquire the expertise required to integrate Industry 4.0 technologies into their existing practises and operations. Conversely, Table 1.3 suggests that opportunities related to Industry 4.0 are available not only to firms at the frontier, but also to those with more basic technological capabilities and innovation practices.

Table 1.3 "The Industry 4.0 journey"

Stage	Typical firm characteristics
Industry 4.0	- Actively engaged in digitalisation and innovation. - Has in-house digital innovation capabilities (e.g. skilled personnel and/or equipment). - **Technologies** currently used by the firm may include: fully automated process lines; advanced sensors and robotics; machine-to-machine (M2M) systems; big data analytics; Internet of things (IoT); real-time web-based relation with suppliers; virtual modelling.
Industry 3.0	- Motivated to engage in digitalisation but lacking resources. - Might have incipient in-house digital innovation capabilities. - **Technologies** currently used by the firm may include: digital system for processing orders, stock and payments; Internet-based support for sales and after-services; enterprise resource planning (ERP) and customer relationship management (CRM); computer-aided manufacturing (CAM); manufacturing execution system (MES); collaborative supply chain management (e.g. SAP, Oracle).

7 The national innovation system (NIS) is the flow of technology and information among people, enterprises and institutions, which is key to the innovative process on a national level.

Industry 1.0–2.0	❯ Lacking the resources to engage in digitalisation. ❯ No in-house digital innovation capabilities. ❯ **Technologies** currently used by the firm may include: basic tools such as spreadsheets and email; basic data-collection systems for shop-floor operations.

Source: Policy Links (2019).

1.6 Conclusions

The term Industry 4.0 has not been used consistently. There is confusion regarding what Industry 4.0 is (and what it is not), and the interfaces with other concepts such as the Fourth Industrial Revolution and the Digital Economy are poorly understood. Sound definitions based on engineering and ICT expertise are required in order to inform relevant areas of policy action and to enable communication and collaboration between stakeholders.

SECTION 2
INDUSTRY 4.0 IN DEVELOPING COUNTRIES – OPPORTUNITIES AND CHALLENGES

Key points of this section

- Potential opportunities enabled by the adaption and adoption of Industry 4.0 in developing countries include: gains in productivity and growth; economic diversification; and contributions to the achievement of the Sustainable Development Goals.
- In manufacturing, opportunities include the development of "smart" products and services; "smart" processes; "smart" supply chains; and "smart" delivery.
- Industry 4.0 technologies create opportunities for an inclusive and sustainable industrialisation, based on a more efficient and productive use of labour, capital and natural resources, and the generation of new products and services.
- Beyond manufacturing, digital technologies are being used to improve the provision of public services and for addressing societal problems.
- Industry 4.0 is raising expectations as well as concerns. Both pessimistic and optimistic views can be identified regarding the potential effect of Industry 4.0 across a number of themes: *the number and quality of jobs; the role of manufacturing as a driver of development; inequality between and within countries; market concentration;* and *gender inequality.*
- In order to realise these benefits, developing countries are faced with barriers, including: improving industrial infrastructure; improving regulatory frameworks; investing in human capital for the creation and use of knowledge; developing technology transfer mechanisms; and easing financial constraints.

2.1 Introduction

Potential gains from the adoption of Industry 4.0 technologies have raised expectations in countries around the world. While a handful of developed countries and China are considered to be at the forefront of Industry 4.0, developing countries are also expected to benefit from digital technologies.[8]

In fact, emerging economies such as Thailand, Mexico and Brazil have significantly increased their rates of robot adoption in recent years. [9]Increases in productivity and growth, economic diversification and new and more efficient ways to address societal challenges are among the potential opportunities arising from the adaption and adoption of Industry 4.0 in developing countries. According to some estimations, productivity increases from new technologies could have an economic impact of up to US$625 billion in the ASEAN[10] region alone by 2030.[11]

8 UNIDO (2019b). *Industrial Development Report 2020.* United Nations Industrial Development Organisation. Vienna.
9 Atkinson, R. (2019). *Robotics and the Future of Production and Work.* Information Technology & Innovation Foundation.
10 Association of Southeast Asian Nations.
11 Chang, J. et al. (2016). *ASEAN in Transformation. How technology is changing jobs and enterprises.* Geneva: International Labour Office.

However, there is still a high degree of uncertainty about the form and scale of the impact for particular countries. Based on a review of the international literature, this section examines the opportunities emerging from the adaptation and adoption of Industry 4.0 for developing countries. Given the relevance to Cambodia, the discussion is extended to economic sectors and activities beyond manufacturing (including the provision of public services and the contribution to sustainable development) and to digital technologies beyond Industry 4.0. Barriers to the development, diffusion and deployment of Industry 4.0 technologies are also discussed.

Industry 4.0 is raising expectations as well as concerns. This section concludes by contrasting "optimistic" and "pessimistic" views on the potential impacts of Industry 4.0 and related technologies, with a particular emphasis on developing countries. Five areas are examined: *the number and quality of jobs; the role of manufacturing as a driver of development; inequality between and within countries; market concentration;* and *gender inequality.*

2.2 Opportunities for developing countries – manufacturing

Industry 4.0 technologies create opportunities for an inclusive and sustainable industrialisation, based on a more efficient and productive use of labour, capital and natural resources and the generation of new products and services.

Industry 4.0 technologies create opportunities for an inclusive and sustainable industrialisation, based on a more efficient and productive use of labour, capital and natural resources and the generation of new products and services. Industry 4.0 technologies can boost manufacturing productivity, increase growth and improve the variety and quality of the goods and services available for consumers.[12]

Table 2.1 shows examples of Industry 4.0 opportunities from selected applications, grouped into four categories introduced in Section 1: i) "smart" products and services; ii) "smart" processes; iii) "smart" supply chains; and iv) "smart" delivery.

12 UNIDO (2019b). *Industrial Development Report 2020. Industrializing in the digital age. Overview.* Vienna.

Table 2.1 Selected opportunities for manufacturing enabled by Industry 4.0

Opportunity areas			Example applications
Manufacturing	"Smart" products and services	Enriched product mix and better products	• Mass-customised products through 3D printing, laser cutting, CNC milling and robotic assembly; • Customisation and cosmetic improvements in 3D-printed hearing aids; • Provision of manufacturing-related services.
		Accelerated product development	• 3D printing for rapid, iterative and more energy-efficient prototyping.
		Improved quality control	• Real-time quality control based on big data analytics.
	"Smart "processes	Enhanced capital utilisation	• Applications for predictive maintenance.
		Improved decision-making	• Improved understanding of risk-taking behaviour through IoT and big data analysis; • AI for better resource allocation.
		Improved skills development	• Augmented reality training tools.
		Enhanced worker welfare	• Robotics and exoskeletons can reduce the need for workers to carry out dangerous physical tasks; • Augmented reality to improve ergonomics at work; • Smart wearables to monitor workers' fatigue, fall detection and air quality.
		Reduced impact on the environment	• Computer-controlled knitted technology that enables a shoe piece to be produced using a single thread; • Automated cutting machines to reduce waste during the cutting process in the garment industry.
	"Smart" supply chains	Improved supply chain management	• Tracking applications, for example, sensors and radio frequency identification (RFID) tags; • Scenario assessments of the environmental and financial impact of changes in supply chains.
	"Smart" delivery	Improved anticipation of customer needs	• Automated ordering; • Real-time feedback from consumer products.

Source: Chang, J. et al. (2016). *ASEAN in Transformation. How technology is changing jobs and enterprises*. Geneva: International Labour Office; ILO (2019b). *Safety and health at the heart of the future of work. Building on 100 years of experience*. Geneva: ILO; UNIDO (2017). *Industry 4.0 opportunities behind the challenge*. Background paper; World Economic Forum (2016a). *Digital Transformation of Industries: Societal Implications*.

2.3 Opportunities for developing countries – other economic sectors and activities

Increased use of Industry 4.0 technologies in manufacturing could also create opportunities to deploy these technologies in other areas. Table 2.2 presents opportunities from selected applications across selected economic sectors and activities.

In agriculture, which represents a large sector in ASEAN economies, sensor technology is allowing farmers to improve their water management and to increase their efficiency and productivity through more precise monitoring of the condition of soil and crops. Opportunities also exist along other segments of the agri-food value chain, with sensors and global positioning tracking systems facilitating the traceability of food products and contributing to food safety.

The integration of different technologies represents opportunities for extending the coverage, and improving the quality, of basic services delivered to citizens. For example, drones are enabling remote areas to be reached faster, while 3D printing is being applied to the production of low-cost prosthetics and rain-water collectors and to facilitate learning.

Table 2.2 Opportunities from Industry 4.0 and other digital technologies in selected application areas

Application areas		Opportunities	Example applications
Economic sectors	Agriculture	Increased efficiency and productivity	Sensor technology has allowed farmers to improve precision in monitoring soil, crops and livestock; Just-in-time irrigation in agriculture through geographical information systems and sensor networks; Blockchain-enabled traceability can reduce food loss.
		Facilitated access to markets and value-chain upgrading	E-commerce platforms that use blockchain-enabled contracts to facilitate interactions among actors in the value chain.
		Improved food safety	Sensors and global positioning system (GPS) tracking applications to improve the traceability of food products.
	Retail	Improved customer experience	Tracking applications for more efficient inventory management and shipment delivery; Virtual retail locations.
	Finance	Improved customer experience	AI to assist service agents in finding answers to customer queries.

	Transportation	Improved mobility	Crowdsourcing of traffic conditions.
		Increased connectivity	Drones to reach remote areas.
Public services		Increased safety	Self-driving vehicles have the potential to increase safety on the roads; Wearable devices to detect "microsleeps" in truck drivers and heavy machinery operators.
	Energy	Reduced energy consumption	Smart meters and temperature sensors that help to reduce energy consumption through message-based alerts.
		Decentralised and more efficient infrastructure	Smart microgrids enable the more efficient distribution of power.
	Health care	Improved health services	AI and big data analytics to improve the detection and treatment of diseases; Cloud-enabled primary health care.
		Reduced production costs	3D printing to produce low-cost prosthetics.
	Water management	Improved monitoring of water resources	Mapping water resources and weather forecasting through remote and *in situ* sensing systems; Water-quality monitoring using sensor networks.
		Meeting the demand for water better	3D-printed rain-water collectors; Smart pipes; Smart meters.
	Education	Better and more inclusive education	3D printing to make abstract concepts concrete for students to explore, particularly visually impaired students; Augmented reality to improve learning experiences and facilitate independent learning.

Source: ADB – World Economic Forum (2017). *ASEAN 4.0: What does the Fourth Industrial Revolution mean for regional economic integration?* White paper; Chang, J. et al. (2016). *ASEAN in Transformation. How technology is changing jobs and enterprises*. Geneva: International Labour Office; ILO (2019b). *Safety and health at the heart of the future of work. Building on 100 years of experience*. Geneva: ILO; UNCTAD. (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development*. Switzerland: United Nations; UNCTAD. (2017). *Information Economy Report. Digitalization, trade and development*. Switzerland: United Nations; UNIDO (2017). *Industry 4.0 opportunities behind the challenge*. Background paper.

Among others, international organisations are increasingly interested in leveraging Industry 4.0-related technologies to tackle some of the most pressing societal problems.[13] Box 2.1 provides examples of how these new technologies can be used to make progress in the achievement of the Sustainable Development Goals (SDGs). Industry 4.0-related technologies, for example, are being used to tackle complex issues such as humanitarian conflicts, by improving monitoring and managing, and also to reach remote areas. ASEAN countries have large rural populations in remote areas that have limited access to electricity. In Cambodia and Myanmar only around half of the population has access to electricity.[14] The integration of different technologies is enabling the rural–urban divide to be bridged, through the development of a decentralised and more efficient power infrastructure.

Industry 4.0 technologies also create opportunities for international organisations. For example, digital platforms are facilitating the participation of beneficiaries and grass-roots organisations in the design, monitoring and implementation of development projects, while remote-sensing imagery and machine learning are reducing the overhead costs of development interventions and improving targeting.

2.3.1 Opportunities for leapfrogging?

Some analysts have highlighted the opportunities that Industry 4.0 may create for "leapfrogging" to more advanced stages of industrial development without going through intermediate states.[15] The Republic of Korea and Taiwan Province of China are often cited as examples of countries that leapfrogged into sectors such as semiconductors and other high-tech electronic goods.[16] However, leapfrogging in the industrial sector is a complex process that requires the accumulation of production and innovation capabilities.[17] The evidence, however, is not conclusive.

Gains from the adoption of technologies are believed to be greater for adopters that are farther away from the technological frontier; however, evidence has also shown that lower capabilities prevent innovation investments and the related returns from being realised.[18] This innovation "paradox"[19] faced by developing countries means that in order to reap the full benefits of Industry 4.0, developing countries will need to accumulate production and innovation capabilities while developing a wider set of contextual enablers.

The impact of technology applications in sustainable development is constrained by the existing capabilities and institutions. Technology adoption without the required skills development, organisational changes, infrastructure improvements and institutional reforms has a limited impact and risks reinforcing the existing inequalities.[20]

13 World Bank (2016). *World Development Report 2016: Digital Dividends*. Washington, DC: International Bank for Reconstruction and Development/World Bank.
14 Chang, J. et al. (2016). *ASEAN in Transformation. How technology is changing jobs and enterprises*. Geneva: International Labour Office.
15 ADB – World Economic Forum (2017). *ASEAN 4.0: What does the Fourth Industrial Revolution mean for regional economic integration?* White paper.
16 UNCTAD (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development*. Switzerland: United Nations.
17 Ibid.
18 Cirera, X. and Maloney, W. (2017). *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC: World Bank.
19 Ibid.
20 Ibid.

Box 2.1 4IR for the SDGs

The High-level Political Forum is the United Nations central platform for monitoring progress in the achievement of the Sustainable Development Goals (SDGs). In 2019 the Forum focused on assessing the progress of 6 of the 17 SDGs:

- Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 10. Reduce inequality within and among countries.
- Goal 13. Take urgent action to combat climate change and its impacts.
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- Goal 17. Strengthen the means of implementation and revitalise the global partnership for sustainable development.

Figure B1.1 shows some examples of how 4IR technologies can contribute to achieving these six SDGs.

Figure B1.1 Examples of how Industry 4.0-related technologies can contribute to achieving the SDGs

SUSTAINABLE DEVELOPMENT GOALS	Industry 4.0-related technologies
4 QUALITY EDUCATION	3D printing to make abstract concepts concrete for students to explore, particularly for visually impaired students; Augmented reality to improve learning experiences and facilitate independent learning; Digital monitoring to reduce absenteeism of teachers.
8 DECENT WORK AND ECONOMIC GROWTH	Digitally integrated systems to improve value chains efficiency by enabling the tracking of goods and payments; ICT-enabled price dissemination to secure fair prices in agriculture; Cloud computing to make business services more accessible to SMEs; Automation of tasks reduces the need for humans to perform dangerous work; Production and trade of new goods and services; Costs savings and productivity increases due to more efficient processes.
10 REDUCED INEQUALITIES	Cloud computing to make business services more accessible to SMEs; ICT-enabled financial services to facilitate access to finance to SMEs –including small farmers –; Blockchain-enabled payments to facilitate the participation of SMEs in global value chains; Digital platforms to reach customers and to participate in the labour market; Descentralised and more efficient infrastructure to bridge the rural-urban divide.
13 CLIMATE ACTION	Big data analysis to monitor natural systems and improve the efficiency of resource use; Blockchain technologies to enable cost-effective and transparent carbon emissions tracking; Smart urban transport systems that integrate multiple technologies to reduce accidents, congestion and pollution; Remote sensing and unmanned aerial vehicles to monitor air pollution.
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Automation of government processes to reduce discretion and rent-seeking behaviours, particularly in those processes involving routine tasks; Digitally integrated systems for services delivery to help governments and development partners to reach citizens in remote areas; Crowdsourced information and big data to improve monitoring and managing of human conflicts and weather inclemencies.
17 PARTNERSHIPS FOR THE GOALS	Digital platforms to involve beneficiaries and grassroots organisations in the design, monitoring and implementation of development projects; Remote-sensing imagery and machine learning to reduce overhead costs of development interventions and improve targeting; Open-source systems to monitor the SDGs.

Source: ADB – World Economic Forum (2017). *ASEAN 4.0: What does the Fourth Industrial Revolution mean for regional economic integration?* White paper; Japan Science and Technology Agency (2018). *Book of Japan's Practices for SDGs - Creating Shared Value by STI, Business and Social Innovation.* Tokyo: JST; UNCTAD (2017b). *Information Economy Report. Digitalization, trade and development.* Switzerland: United Nations; UNCTAD (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development.* Switzerland: United Nations; World Bank (2016). *World Development Report 2016: Digital Dividends.* Washington, DC: International Bank for Reconstruction and Development/World Bank.

2.4 The challenges ahead for developing countries

The participation of developing countries in the benefits of Industry 4.0 requires barriers to developing, diffusing and deploying technologies to be overcome. These include: inadequate infrastructure, skills gaps, underdeveloped regulatory frameworks, limited technology transfer mechanisms and financial constraints.

Developing countries need to overcome various barriers in order to take advantage of Industry 4.0 technologies. The adoption of digital technologies in manufacturing occurs in the context of enabling national conditions that facilitate the development of new technologies, and their diffusion and deployment by industrial users (Box 2.2).

The development of new technologies is particularly difficult for developing countries where basic innovation capabilities are still in the nascent stages.[21] Endogenous knowledge generation is usually scarce and there are limited – or no – technology transfer mechanisms. As a result, developing countries tend to rely on imported technologies, making the process of adaptation and adoption more challenging, considering the cultural and physical distances between the technology developers and the adopters.[22]

In a rapidly changing work landscape, skills mismatches are becoming more frequent in both developing and developed countries; however, gaps tend to be broader in developing countries. Skills gaps range from scientific and technological knowledge to managerial and communication expertise, representing barriers for both the development and deployment of new technologies. The adoption of Industry 4.0 technologies adds new skills requirements, such as digital literacy, soft skills (e.g. interpersonal) and advanced cognitive skills.[23]

Underdeveloped institutional frameworks are a common barrier to the diffusion of new technologies in developing countries. [24]Regulatory challenges specific to Industry 4.0 technologies include: standards that ensure interoperability among technology systems; regulations that address the health and safety issues of human–machine interactions; responsive intellectual property; cyber security, data protection and data privacy frameworks; and regulations that address ethical concerns related to human biases embedded in AI and data analytics.

In the least developed countries, limited basic and digital infrastructure represents additional barriers to diffusing and deploying technologies, such as: unstable electricity provision; inadequate roads network; and slow and costly Internet services with restricted geographical coverage.[25]

Constrained government budgets and difficult access to credits, conditions that are frequently found in developing countries, constitute an additional barrier to the investments needed to develop and deploy Industry 4.0 technologies.[26]

21 UNCTAD (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development.* Switzerland: United Nations.
22 UNIDO (2019b). *Industrial Development Report 2020. Industrializing in the digital age. Overview.* Vienna: UNIDO.
23 UNCTAD (2018). *Op. cit.*
24 Ibid.
25 Asian Development Bank – World Economic Forum (2017). ASEAN 4.0: *What does the Fourth Industrial Revolution mean for regional economic integration?* White paper.
26 UNIDO (2019b). *Op. cit.*

Box 2.2 Key barriers to exploiting Industry 4.0 technologies in developing countries

Barriers to developing new technologies

- Scarce endogenous knowledge generation;
- Dependence on foreign technology;
- Low R&D investment;
- Shortage of STEM professionals.

Barriers to diffusing new technologies

- Lack of awareness about technologies and the potential benefits of using them;
- Underdeveloped cyber security, data protection and data privacy regulation;
- Lack of standards that ensure interoperability among technology systems;
- Evolving definitions of intellectual property, which will need responsive frameworks;
- Limited and costly Internet services.

Barriers to deploying new technologies

- Absent technology transfer mechanisms;
- Limited access to facilities to test advanced solutions;
- Emerging health and safety issues of human–machine interactions;
- Ethical concerns related to human biases embedded in AI and data analytics;
- Gaps in skills, such as: digital, foreign languages, management, soft and advanced cognitive;
- Limited capacity of SMEs to attract talent;
- Unstable electricity supply with limited coverage;
- Financial constraints, especially among SMEs.

Source: ADB – World Economic Forum (2017). *ASEAN 4.0: What does the Fourth Industrial Revolution mean for regional economic integration?*White paper; UNIDO (2019b). *Industrial Development Report 2020. Industrializing in the digital age. Overview.* Vienna; UNIDO (2017). *Industry 4.0 opportunities behind the challenge.* Background paper.

2.5 Opposing views on Industry 4.0 impacts

There is uncertainty about the potential impacts of the adoption of Industry 4.0 technologies. Early studies warned of massive job losses; however, more detailed insights have predicted slower and less disruptive transformations. Transformations in production systems, trade networks and labour relations are likely to create opportunities for economic and social inclusion, but they may also involve risks of deepening existing inequalities. Responsive education and training programmes, social protection and business support interventions have a role to play in leaving no one behind in the Industry 4.0 journey.

As well as raising expectations on the potential positive impacts of the adoption of Industry 4.0 technologies, increasing interest in Industry 4.0 is raising concerns about the potential risks of the widespread deployment of these technologies for developing countries. The main concerns are around: massive job losses; changes in the type and quality of jobs; narrowing opportunities to participate in manufacturing global value chains; and the related widening of existing inequalities.

Although the adoption of labour-saving technologies will eminently alter production systems, trade networks and labour relations, the pace of these changes is likely to be slower and less disruptive than early studies have predicted.[27] This is particularly relevant in developing contexts – including Factory Asia – where, given the relatively low prices of labour, investments in automation are not yet economically feasible in many industries.[28]

The adoption of Industry 4.0 technologies has the potential to increase returns from education and to allow more capable – usually large – firms to disproportionally benefit from these technologies. However, these technologies also create opportunities for individuals and MSMEs to participate in markets. In addition, responsive education and training programmes, social protection and business support interventions have a role to play in facilitating economic participation and avoiding the widening of inequality gaps.

Table 2.3 summarises some of the key risks facing the adoption of Industry 4.0-related technologies discussed in the literature and presents opposing perspectives that help to provide a more balanced view of the potential impacts of Industry 4.0.

Table 2.3 Opposing views on the impact of the adoption of Industry 4.0-related technologies

Impacts on...	View 1	View 2
Jobs	Predictions about the impact of new technologies on jobs suggest that over 60% of jobs are at high risk of automation in key economic sectors in the ASEAN region.	Predictions about the impact of automation on jobs are far from reaching a consensus, and the methodologies used are controversial, with figures ranging from the creation of over 100 million jobs to the loss of over 200 million.

27 UNCTAD (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development.* Switzerland: United Nations.
28 Atkinson, R. (2019). *Robotics and the Future of Production and Work.* Information Technology & Innovation Foundation.

	• The average price of an industrial robot has fallen by half in real terms, and even more relative to labour costs. • People displaced by automation do not necessarily have the skills to perform the newly created jobs and tasks. • Increased physical hazards from new forms of human–machine interaction and exposure to new materials. • Non-standard work arrangements, such as on-call work, zero-hours contracts, telework and self-employment, increase insecurity for workers and affect their work–life balance.	• The indirect employment effects of automation may outweigh the direct negative effects. • There is a stronger economic case for adopting robots in developed, than developing, economies because investments in robots are often justified by how much they save in labour costs. • Technological change releases human resources that can be employed in sectors with higher returns. It also reduces the need for humans to do physically hard, repetitive or dangerous work. • The production and trade of new products and services will create new job opportunities for those who have, or acquire, the relevant skills.
Role of manufacturing as driver of development	• Labour-saving technologies may reduce the relative importance of wage competitiveness, opening up opportunities for high-income economies to backshore production. • Reductions in the competitiveness of lower-income countries would diminish the role of manufacturing as a driver of export-led development.	• Evidence for backshoring is very limited, and offshoring is still dominant over backshoring. • New technologies are reducing the costs of exporting and improving customs performance by automating document processing. • New trading opportunities may emerge for developing countries, in niche markets and intermediate products.
Inequality between and within countries	• New technologies have the potential to increase returns from education, increasing wealth gaps between high- and low-skilled workers; and between developed and developing countries.	• Digital technologies increase connectivity and facilitate information-sharing, creating opportunities for social and economic inclusion.
Market concentration	• Large companies are better prepared to reap the benefits of new technologies. First-movers may disproportionately benefit, leading to market concentration. • Digital integration in value chains may exclude firms with lower capabilities from adopting digital technologies; increase buyer control; and transfer risks to contractors and subcontractors in terms of stock requirements, unpredictable orders and demand for a rapid turnaround.	• Digital technologies are making business services more accessible to MSMEs and start-ups; facilitating customers being reached; joining global value chains; and lowering the costs of market entry. • SMEs may find larger opportunities in well-defined market segments and those characterised by a diversity of buyers through e-commerce platforms.

Gender inequality	• Women are disproportionately represented in low-skilled occupations performing routine tasks, and thus they face higher risks of job automation than men. • New technologies may increase gender income gaps embedded in social norms that keep women in low-paid, poor-quality jobs.	• Digital technologies have made work more flexible, creating opportunities for women to enter the labour market, especially in white-collar occupations. • Although gender gaps are significant in digital skills, the gaps are lower in soft skills. • Industry 4.0 may create further opportunities to perform new occupations that require more technical skills and less physical work.

Source: Atkinson, R. (2019). *Robotics and the Future of Production and Work*. Information Technology & Innovation Foundation; Chang, J. et al. (2016). *ASEAN in Transformation. How technology is changing jobs and enterprises*. Geneva: International Labour Office; Cliff, V. (2018). *The Fourth Industrial Revolution could smash gender inequality – or deepen it*. World Economic Forum; Hallward-Driemeier, M. and Gaurav, N. (2018). *Trouble in the Making? The Future of Manufacturing-Led Development*. Washington, DC: World Bank; ILO (2019b). *Safety and health at the heart of the future of work. Building on 100 years of experience*. Geneva: ILO; UNCTAD (2018). *Technology and innovation report 2018. Harnessing frontier technologies for sustainable development*. Switzerland: United Nations; UNCTAD (2017b). *Information Economy Report. Digitalization, trade and development*. Switzerland: United Nations; UNIDO (2019b). *Industrial Development Report 2020. Industrializing in the digital age. Overview*. Vienna; UNIDO (2019b). *Inclusive and sustainable development: The gender dimension*; UNIDO (2017). *Industry 4.0 opportunities behind the challenge*. Background paper; World Bank (2016). *World Development Report 2016: Digital Dividends*. Washington, DC: International Bank for Reconstruction and Development/World Bank; World Bank (2019a). *World Development Report 2020. Trading for Development in the Age of Global Value Chains (Draft)*. International Bank for Reconstruction and Development/The World Bank; World Economic Forum (2018a). *The Future of Jobs Report 2018*. Geneva.

2.6 Conclusions

The aim of this section has been to provide a balanced perspective of the opportunities and challenges involved in the adoption of Industry 4.0 and related digital technologies in developing countries. Industry 4.0 has the potential to create opportunities for new and better products and services; for new and better processes; and for more efficient supply chains and delivery. Improvements at firm and industry level are likely to have positive impacts on national productivity, economic growth and diversification. In addition, Industry 4.0 competencies could be extended from manufacturing to other areas of the economy and society.

However, in order to reap the benefits of Industry 4.0 and related technologies, developing countries face several challenges. These include: investing in infrastructure; improving regulatory frameworks; investing in human capital for the creation and use of knowledge; developing technology-transfer mechanisms; and easing financial constraints.

The adaptation and adoption of Industry 4.0 technologies have the potential for both positive and negative effects. In order to take full advantage of the positive impacts, and to reduce the negative, policy interventions are needed that account for country-specific economic structures, societal challenges and innovation system features. Based on previous studies and consultations with local stakeholders, the next two sections analyse Cambodia's specific context, discussing the particular opportunities and challenges involved in the adaptation and adoption of Industry 4.0 in the country.

SECTION 3

CAMBODIA'S CONTEXT – WHY INDUSTRY 4.0 MIGHT BE RELEVANT TO CAMBODIA

Key points of this section

- In recent years Cambodia has experienced high economic growth and made significant progress in reducing poverty and income inequalities.
- However, Cambodia faces some challenges in sustaining its economic development, and further progress needs to be made towards achieving national socio-economic goals.
- The adaptation and adoption of Industry 4.0 present opportunities for Cambodia to upgrade its industrial value chains, diversify its economic structure and create new capabilities for innovation.

3.1 Introduction

Over the last two decades, Cambodia has experienced high economic growth and has substantially reduced poverty and income inequalities. Underpinned by such a strong economic performance, progress has also been made in the area of health, education and environmental protection, as well as towards significant achievements regarding the Sustainable Development Goals.

This section outlines the main progress achieved by Cambodia in recent years in terms of socio-economic development. Given the scope of this report, particular attention is paid to the relative importance of manufacturing in the economy, highlighting its main structural features compared to Cambodia's regional peers.

This section shows that, to be able to sustain its development in the near future, and to ensure further reduction in poverty rates, Cambodia faces some challenges, including:

- Concentration of the economic structure on a few economic sectors, namely, textiles and clothing, and food and beverages, which are labour-intensive and face the competition of other countries in the region;
- A weak domestic supply chain that does not fully benefit from exports (i.e. in textiles and clothing, only 25% of inputs comes from local sources);[29]
- The reduction of funding from international donors following the promotion from being classified as a least-developed country (LDC) to being classified as a lower middle-income economy;[30]
- The erosion of preferential trade agreements associated with being promoted to a lower middle-income country;[31]
- Continuous exposure to severe environmental events associated with climate change and, therefore, difficulties relying on sectors such as tourism as the main engine of growth.

In the national strategies, the Royal Government of Cambodia has recognised the need to diversify and expand the manufacturing base

29 World Bank (2018). *Cambodia's Future Jobs: Linking to the Economy of Tomorrow.* The World Bank Group.
30 World Bank (2017). *Cambodia: Sustained Strong Growth for the Benefits of All.* The World Bank Group.
31 Ibid.

by moving away from labour-intensive industries to those that demand a more skilled workforce.

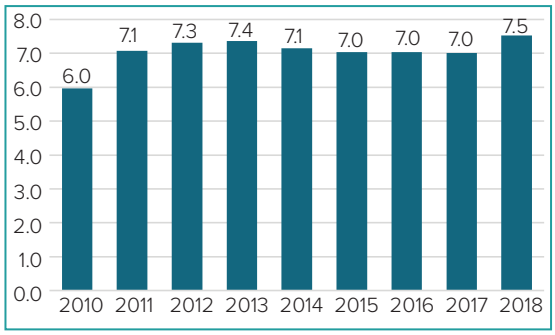
Although manufacturing is just one of the potential priority areas on which to focus policy action in the near future, the adaptation and adoption of Industry 4.0 technologies among firms in Cambodia may help to overcome some of the challenges that the country may face in the future.

3.2 Cambodia's macroeconomic development: an overview

Cambodia has experienced an impressive economic performance in the last decade, with average growth rates above 7% per year. Sustained economic growth has favoured a rise in real per capita income that, in 2018, is more than 53% higher that its levels in 2010, although it is still lower than the ASEAN average.

The Royal Government of Cambodia (RGC) has the ambitious plan of ensuring that the country reaches the status of an upper middle-income economy by 2030 and a high-income country by 2050, moving forward in its path of promoting economic inclusion, as well as environmental sustainability.[32]

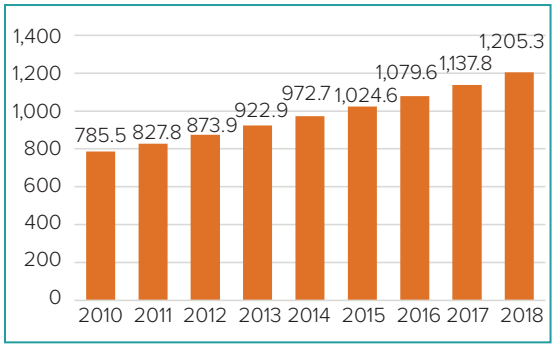
Figure 3.1 Cambodia's GDP growth, 2010–2018 (annual %)



Source: World Bank (2019b). *World Development Indicators.*

After recovering from the global financial crisis in 2009, the economy has experienced sustained economic growth, above 7% annually, in a context of macroeconomic stability and trade and financial openness[33] (Figure 3.1).

Figure 3.2 Cambodia's GDP per capita, 2010–2018 (constant 2010 US$)



Source: World Bank (2019b). *World Development Indicators.*

Sustained economic growth has favoured a rise in per capita income. In 2018 Cambodia's per capita income, in real terms, was more than 53% higher that its levels in 2010 (Figure 3.2), reaching US$1,205, although this is still low compared to the ASEAN average of US$12,199.[34]

Economic growth has contributed to decreasing poverty and income inequalities. In a decade the Cambodian population living below the national poverty line more than halved. This achievement has been accompanied by a more equal income distribution. Major progress has also been recorded in health (i.e. a reduction in infant mortality rates, and a reduction in the HIV/AIDS prevalence rate) and education (i.e. improvement to access to education).

Following the impressive economic

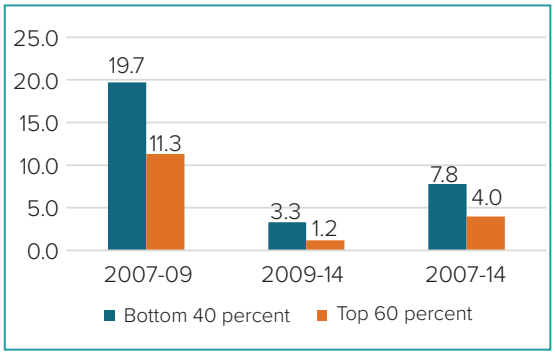
32 RGC (2019). *Cambodia's Voluntary National Review 2019 on the Implementation of the 2030 Agenda for Sustainable Development.*

33 Macroeconomic policy allowed the financial sector to deepen and the opening of current and capital accounts to attract investments and export promotion; meanwhile, trade policy focused on export-orientation, which became a priority when coping with the small domestic market. Cambodia has taken advantage of the intra-regional differences and complementarities related to labour costs, natural resources endowment and trade regulation. Source: Chhair S., and Ung L. (2016). "Cambodia's Path to Industrial Development – Policies, Lessons, and Opportunities". In Newman et al. Manufacturing Transformation: Comparative Studies of Industrial Development in Africa and Emerging Asia. Oxford Scholarship Online.

34 World Bank (2019b). *World Development Indicators.*

performance, a reduction in poverty and income inequalities has been recorded. In just a decade the share of the Cambodian population living below the national poverty line more than halved, going from 30.1% in 2005 to 14% in 2015.[35]

Figure 3.3 Cambodia's growth in consumption per capita (annualised growth %)



Source: RGC (2019). *Cambodia's Voluntary National Review 2019 on the Implementation of the 2030 Agenda for Sustainable Development.*

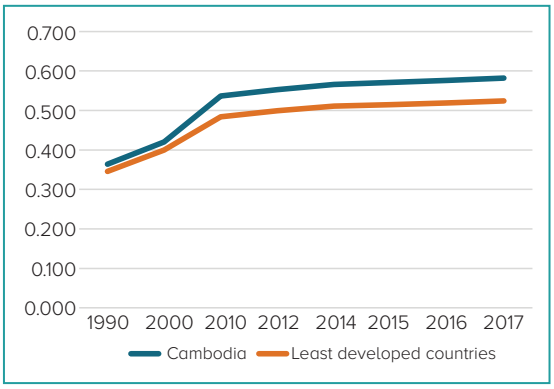
The reduction in poverty was followed by improvements in income inequalities. For example, as shown in the following figure, the consumption of the bottom 40% of the population in the distribution of income has grown faster than the rest of the population.

The reduction in inequalities is supported by the government, with specific interventions such as programmes to build and deliver affordable housing. The "National Ageing Policy 2017–2030" focuses on the need to include ageing in the development planning process; and the aim of the "National Social Protection Policy Framework 2016–2025" is to ensure income security and reduce economic and financial vulnerability of Cambodian citizens.

Strong economic growth, together with a rapid demographic transition, progressive urbanisation and industrialisation, have all contributed to major transformations. Major progress has been observed in health and education too. In terms of health, a reduction in maternal, child and infant mortality rates, and in the HIV/AIDS prevalence rate and malaria incidence, has been recorded. In addition, access to education has also improved.

All these changes are reflected in improvements in the Human Development Index,[36] with Cambodia being among the top ten performers at a global level.[37]

Figure 3.4 Human Development Index, Cambodia and Least Developed Countries



Source: UNDP (2019). *Human Development Index Trends, 1990–2017.*

3.3 Cambodia's progress towards the Sustainable Development Goals

The adoption and diffusion of Industry 4.0 technologies can contribute to the achievement of the Sustainable Development Goals (SDGs). The Royal Government of Cambodia has fully embraced the United Nations' 2030 Agenda for Sustainable Development and its associated 17 SDGs. To date, sustained by strong economic performance, Cambodia has made important progress towards the achievement of the SDGs.

The RGC embraced the United Nations' 2030

35 ADB (various years). *Basic statistics.*

36 The Human Development Index is a composite index, on a scale of 0–1, developed by UNDP, that assesses a country against not only economic growth but also health and knowledge.

37 RGC (2019). *Cambodia's Voluntary National Review 2019 on the Implementation of the 2030 Agenda for Sustainable Development.*

Agenda for Sustainable Development and its associated 17 Sustainable Development Goals (SDGs) with a strong commitment to their achievement. In addition to selecting all of the 17 SDGs, the Cambodian SDGs (CSDGs) Framework 2016–2030 also added an additional goal, related to the clearance of land mines and explosive remnants of war.

In the current *Cambodia's Voluntary National Review (VNR) 2019 of the Implementation of 2030 Agenda,* six SDGs have been prioritised for evaluation following the High-level Political Forum within the United Nations:[38]

- SDG 4 (Quality Education);
- SDG 8 (Decent Work and Economic Growth);
- SDG 10 (Reduced Inequalities);
- SDG 13 (Climate Action);
- SDG 16 (Peace, Justice and Strong Institutions); and
- SDG 17 (Partnerships for the Goals).

The VNR assessed the progress of Cambodia in relation to the 88 nationally relevant targets, and 148 globally and locally defined indicators of SDGs, where the goals for each of the SDGs are classified as:

- *On track*: where target indicators are close to the specified milestone data;
- *Ahead of track*: where target indicators are generally 10% ahead of the milestone data;
- *Below track*: where target indicators are generally 10% below the milestone data.

To date, 61.3% of the prioritised SDG targets are "ahead" or "on track".

Table 3.1 summarises the progress and challenges in relation to the achievement of the six SDGs assessed this year.

Table 3.1 Cambodia's progress towards the six prioritised SDGs

SDGs	Progress and challenges	Progress toward SDGs*			
		No data	Below track	On track	Ahead
SDG 4 Quality Education	**Progress** Significant progress in the education sector, to include improvements in educational attainment and competition rate, as well as in gender parity education. **Challenges** Inclusive access to education; transition from primary to lower-secondary and high drop-out rates; quality of teaching; life-long learning.	14.3%	--	--	88.7%
SDG 8 Decent Work and Economic Growth	**Progress** Impressive economic growth and dramatic reduction in poverty rates. **Challenges** Diversifying and expanding the manufacturing base and moving towards higher valued–added, and more technology-intensive products; reducing the number of informal companies; further progress needed to implement *The Industrial Development Policy (IDP) 2015–2025;* investing in infrastructure to increase and diversify the tourist sector.	20%	20%	20%	20%

38 United Nations' High-level Political Forum on Sustainable Development 2019.

SDG 10 **Reduced Inequalities**	**Progress** Reduction of inequality; distribution of land titles to Cambodian citizens; programmes to build and deliver affordable housing; programmes to guarantee income security and to reduce the economic and financial vulnerability of Cambodian citizens. **Challenges** Closing the social and economic gap between households living in urban and rural areas; limited coverage of social services across the population.	40%	--	--	60%
SDG 13 **Climate Action**	**Progress** Climate change has been fully integrated in the national strategies and policies; annual public expenditure for climate change has increased; initial progress on the reduction of greenhouse gas (GHG) emissions. **Challenges** Cambodia is one of the most vulnerable countries to climate change, among the top 10 in the world; there is a lack of technological and human resources capabilities to implement adaptation and mitigation solutions; financial support from developed countries is not sufficient.	100%	--	--	--
SDG 16 **Peace, Justice and Strong Institutions**	**Progress** Dramatic improvements have been made to consolidate peace, political stability and social order; to ensure justice for all Cambodian citizens; considerable emphasis has been put on improving human rights; and ensuring freedom of associations and political rights. **Challenges** Fighting corruption remains one of the main challenges ahead, also because of a lack of budget to enforce the existing law.	--	--	66.7%	33.3%
SDG 17 **Partnerships for the Goals**	**Progress** Substantial success in strengthening development partnerships to implement key policies; increased national budget to engage with the Cambodian population to inform policy development (i.e. 2019 general population census). **Challenges** Need to mobilise an increasing level of financial resources and apply a more complex financial management system to be sure of fully achieving the SDGs.	--	--	66.7%	33.3%

Note: * Authors' calculation based on RGC (2019). Values in table add up to 100%. Progress towards the SDGs is measured against a number of measurable indicators based on the data available in Cambodia's Voluntary National Review; the share of indicators that are ahead, on track and below track was calculated for each of the prioritised SDGs.
Source: RGC (2019). *Cambodia's Voluntary National Review 2019 on the Implementation of the 2030 Agenda for Sustainable Development.*

As discussed in Section 2, the adoption and diffusion of Industry 4.0 technologies can contribute to achieving the SDGs. A range of technologies has been analysed in the literature regarding how they could impact specific targets of the SGDs. Therefore, promoting the adoption and diffusion of such technologies could further sustain Cambodia's path towards achieving the SDGs and overcoming the challenges ahead.

The commitment of the RGC to achieving the SDGs creates both opportunities and challenges. The VNR highlights three main areas that policy action should focus on:

1. Progress towards the SGDs so far has been sustained by the very good economic performance of the country – economic growth, private sector investments and increasing public revenue – whose benefits spread to the whole population in terms of reduced poverty and inequality. These achievements are underpinned by structural changes in the economy towards high-value-added activities and Cambodia's young population. The challenge ahead is to sustain in the long term such a development path, given the lack of human resources and financing opportunities needed to fully implement the SDG agenda.

2. Climate change remains a major challenge, given its impact on many SDGs, despite progress undertaken by the RDG in implementing policies to cope with it. The country remains exposed to severe climatic events, as well as the environmental degradation associated with rapid economic growth.

3. Cambodia has made considerable investments in public sector management reforms and system strengthening. However, the challenge for the future is to ensure that all the actors are fully involved in all aspects concerning governance of the SDGs.

3.4 Cambodia's structure of the economy and recent trends

Cambodia's manufacturing has experienced structural transformation in recent decades, providing a substantial contribution to the economy's GDP. However, some structural constraints remain that could hamper future manufacturing growth. Examples include a small dimension of domestic firms against a majority of large firms with foreign ownership; relatively low labour productivity among firms; weak linkages between domestic supply chains and foreign companies attracted by foreign direct investments; and manufacturing exports concentrated towards low–value–added goods. The adaptation and adoption of Industry 4.0 technologies may help with overcoming some of these constraints.

In recent years the economy of Cambodia has experienced significant structural changes that have had impacts across sectors.[39] Figure 3.5 shows how both agriculture[40] and manufacturing (i.e. excluding construction) still play an important role where their contribution to the economy is concerned.

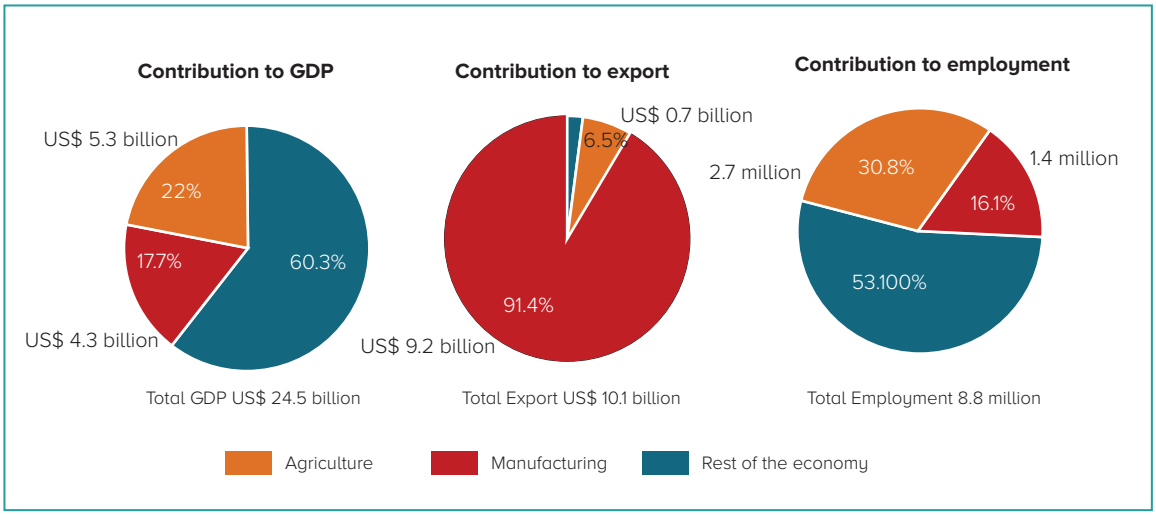
Manufacturing:

- Contributes to 17.7% of Cambodia's GDP;
- Provides 1.4 million jobs (16.1% of total employment in the country);
- Is the main contributor to exports, with a value of US$9.2 billion, equal to 91.4% of total exports.

39 See Chhair S. and Ung L. (2016). "Cambodia's Path to Industrial Development – Policies, Lessons, and Opportunities". In Newman *et al.* (2016). Manufacturing Transformation: Comparative Studies of Industrial Development in Africa and Emerging Asia. Oxford Scholarship Online

40 Analysis of the agricultural sector is outside the scope of this report. For an overview of the main structural changes that the sector has faced in recent years, see, among others: World Bank (2015). *Cambodian Agriculture in Transition: Opportunities and Risks*. The World Bank Group.

Figure 3.5 Cambodia's manufacturing contribution to the economy

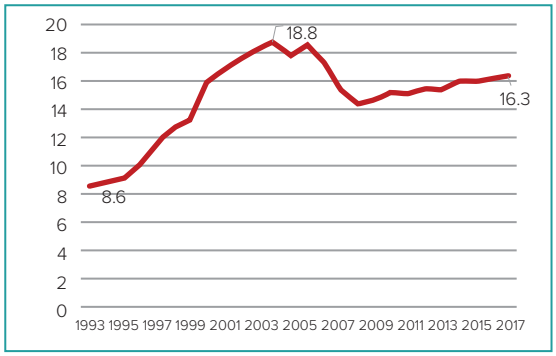


Source: World Bank (2019b). *World Development Indicators*; World Bank (2019c). *World Integrated Trade Solution*; ILO (2019a). ILOSTAT

Manufacturing has experienced an important structural transformation in the recent history of Cambodia's industrialisation (Figure 3.6). Sector development has been influenced by policies adopted by the RGC soon after the first general elections in 1993. At that time, the government implemented macroeconomic and structural reform programmes. For example, trade policies were further liberalised (reinforcing 1987 policies that abolished the state monopoly on foreign trade). In the same years, industrialisation was promoted though the attraction of foreign direct investments (FDI).

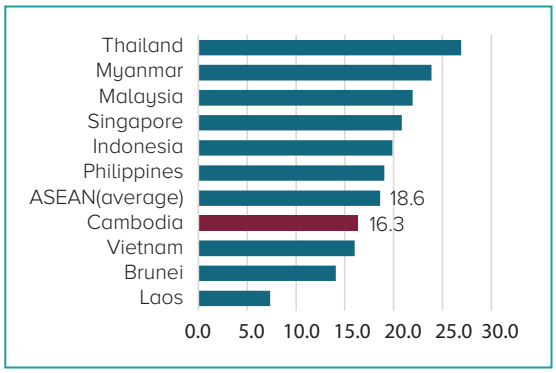
Later on, manufacturing was also impacted by Cambodia's integration into the ASEAN free trade area in 1999, and its accession to the WTO in 2003. Accession to the above trade organisations imposed further liberalisation of trade and capital accounts that led to a surge in FDIs.[41] During this long phase, Cambodia's share of manufacturing value-added in GDP went from 8.6% in 1993 to 18.8% in 2004. Later on, the economy was impacted by the negative effects of the global financial crisis in 2007–9. The manufacturing share in GDP has been increasing since then, although its value in 2018 – 16.3% – was still lower than its peak in 2004 (Figure 3.7).

Figure 3.6 Cambodia's manufacturing value added (% of GDP)



Source: World Bank (2019b). *World Development Indicators.*

Figure 3.7 ASEAN – manufacturing value added (% of GDP), 2018

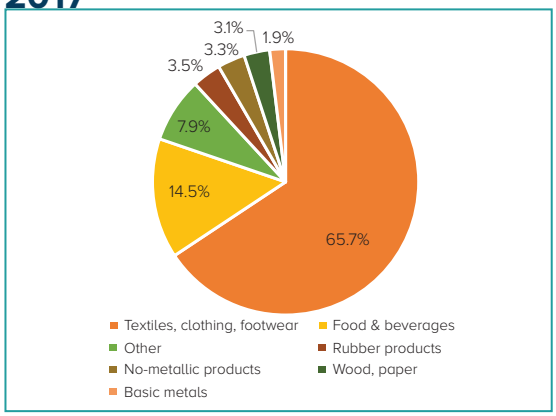


Source: World Bank (2019b). *World Development Indicators.*

41 For a detailed review of Cambodia's industrialisation from a historical perspective, see Chhair S. and Ung L. (2016). "Cambodia's Path to Industrial Development – Policies, Lessons, and Opportunities". In Newman et al. *Manufacturing Transformation: Comparative Studies of Industrial Development in Africa and Emerging Asia.* Oxford Scholarship Online.

Although Cambodia has experienced industrialisation in the past two decades, compared to its regional peers, Cambodia's manufacturing share of GDP is below the ASEAN average (18.6% in 2018) (Figure 3.7).

Figure 3.8 Cambodia's manufacturing value added in 2017



Source: NIS (2019). National Account.

Focusing on manufacturing composition, Figure 3.8 shows how Cambodia's manufacturing structure remains narrow and concentrated in two main sectors:

- Textiles, clothing and footwear, together with food and beverages, make up 80% of manufacturing value added.
- These sectors are also the largest employers of the 1.4 million workers in manufacturing.

The manufacturing sector is also characterised by the small size of the companies. Based on the most recent data available, there are 705,511 manufacturing firms in Cambodia, 99% of which are classified as micro-enterprises with fewer than 10 employees; meanwhile, there are only 609 firms with more than 100 employees. This means that Cambodian manufacturing is reliant upon a few large enterprises, which renders the whole industrial structure weak, should any of the larger firms close a plant or decide to relocate abroad.[42]

With regard to the ownership structure, the majority (63%) of large enterprises is owned by foreign companies, while Cambodia's residents own almost the majority of micro and small enterprises. Of this, 63% of large enterprises are owned by foreign companies, 47% are Chinese and 12.5% are Korean and other Asian nationalities.[43] In other words, Cambodia's manufacturing is characterised by being reliant upon a relatively small number of large companies, the majority of which are foreign owned.

When compared to its regional peers, Cambodia's firms also present a relatively lower level of labour productivity levels and productivity growth. Although similar to countries such as Myanmar and Bangladesh, Cambodia lags behind Viet Nam and the Philippines. Factors that can explain such a dynamic include: Cambodia's structural low labour productivity growth – for example, between 1993 and 2015, Cambodia's productivity grew at an average 3.6% per year against 5% average annual growth in Viet Nam and 7% in Thailand during the same years; the export basket of Cambodia is concentrated towards sectors such as textiles, which present low productivity gains; the country's overall productivity gains in recent years were supported not by manufacturing but by real estate and the financial sector; and, finally, the business environment may also be a constraint to investments.[44]

Domestic firms do not have strong linkages with FDI firms that dominate the export sector. In the textiles and clothing sector, for example, only 25% of inputs come from local sources, as opposed to 60% in Viet Nam, 62% in Bangladesh and 100% in India.[45] In other words, domestic firms do not engage with FDI firms, which dominate the textile and clothing sector. This may be due to the fact that foreign firms rely more on their global suppliers than on domestic firms.

Regarding international trade, data shows that Cambodia's external sector is characterised by structural current account imbalances, mainly driven by a trade deficit. In 2018 Cambodia's current account deficit represented 11.3% of the GDP.[46]

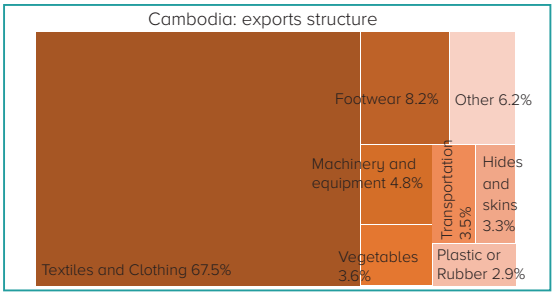
However, the overall balance of payments presents surpluses that are mainly funded by the recent surge in foreign direct investments

42 RGC (2015). *Cambodia Industrial Development Policy 2015–2025.*
43 Chhair S. and Ung L. (2016). *Op. cit.*
44 World Bank (2018). *Cambodia's Future Jobs: Linking to the Economy of Tomorrow.* The World Bank Group
45 Ibid.
46 ADB (2019). *Cambodia – key indicators.*

(FDI). In 2018 FDI represented two-thirds of approved private investments in the country. In the real sector, the targeted sectors for investments are construction, real estate and tourism. Investments in the construction sector boosted growth in manufacturing (i.e. building material, furniture, metal and plastic products).[47]

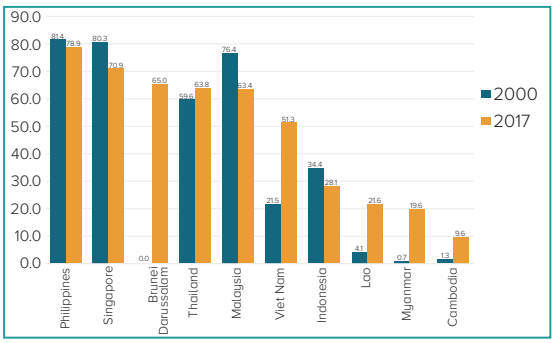
The structure of exports is concentrated towards textiles, clothing and footwear, which represent 75.7% of total exports.

Figure 3.9 Cambodia's structure of exports, 2016



Source: World Bank (2019c). *World Integrated Trade Solution.*

Figure 3.10 ASEAN – medium and high-tech exports (% manufactured exports), 2000 and 2017



Source: World Bank (2019b). *World Development Indicators.*

Cambodia's exports are concentrated towards lower valued added productions. Figure 3.10 shows the share of medium and high-technology exports in total manufacturing exports among ASEAN countries.[48] Between 2000 and 2017, Cambodia was able to increase the value added of manufacturing goods exported.

In 2017 only 9.6% of manufacturing exports were classified as medium- and high-technology intensive, this being the lowest value among ASEAN countries. The structure of imports, in contrast, is more diversified, with machinery and equipment, and transport, representing 21.4% of total imports.

3.5 Conclusions

The opportunities and challenges behind the country's recent impressive economic development are being addressed by the Royal Government of Cambodia (RGC). While it is true that the benefits of economic growth have spread to the whole population, the challenge that lies ahead is to ensure that such economic growth will be sustainable in the future. In this respect, RGC aims to achieve the Cambodia Vision 2030 and 2050, ensuring sustained growth, employment, equity and efficiency. To this end, a set of fully integrated national policies has been implemented to ensure long-term economic growth, sustainability and economic inclusion.

Cambodia's policies recognise the relevant contribution of manufacturing to economic growth, technological upgrading and diversification. Cambodia's manufacturing sector is the focus of the *Cambodia Industrial Development Policy 2015–2025 (IDP)*. The IDP is based on the vision that it is necessary to transform and upgrade the manufacturing structure, which is specialised in a few labour-intensive industries, towards a more diversified and skills-driven industry by 2025.[49] The adaptation and adoption of Industry 4.0 can be a useful strategy in achieving this vision.

Industry 4.0 may also provide an opportunity to facilitate the participation of SMEs in global value chains, through the adoption of state-of-the-art technology; and overall, to make Cambodia's firms and sectors more competitive in international markets, reducing trade imbalances.

The opportunity to leverage digital technologies in manufacturing is recognised in government policies; however, a specific Industry 4.0 strategy would complement ongoing efforts to address the particular challenges found in the adoption of technologies in manufacturing.

47 World Bank (2019d). *Investing in Cambodia's Future: Early Childhood Health and Nutrition. Recent Economic Developments and Outlook.* The World Bank Group.

48 The UNIDO classification of manufacturing sectors by technological intensity (ISIC Revision 4) is available at the following link: https://goo.gl/uVSQtG.

49 RGC (2015). *Cambodia Industrial Development Policy 2015–2025.*

SECTION 4
CAMBODIA'S READINESS FOR INDUSTRY 4.0 – A PRELIMINARY ASSESSMENT

Key points of this section

- The successful adaptation and adoption of Industry 4.0 in Cambodia will require efforts to raise awareness of digital technologies and their benefits; to make these technologies more widely accessible; and to develop the skills needed to use them.
- These efforts will be required in parallel with initiatives – some of which are already in progress – to invest in basic and digital infrastructure; to improve the institutional framework; to relax financial constraints; and to strengthen linkages between innovation actors.

4.1 Introduction

It can be argued that, when it comes to technology adaptation and adoption, developing countries face more complex challenges than developed countries, but also broader opportunities. Physical and human capital endowments tend to be lower than in developed countries, and innovation activities performed by firms do not usually involve R&D or licensing.[50] Thus, a narrow focus on R&D in innovation policies risks wasting limited resources. An accumulative approach to production and innovation capabilities, in contrast, has proved to be more effective, as the catch-up experience of countries such as South Korea, Singapore, Hong Kong and Taiwan Province of China has evidenced.[51]

Technology adaptation and adoption can be understood as a multi-level process that involves overcoming barriers at both firm and national system level. Technology adoption occurs in the context of a national innovation system, that is, the network of actors and institutions – and their interactions – involved in the process through which knowledge is generated, diffused and used.[52] Adopting a new technology may require not only R&D expertise to identify and modify the technology to the local context but also availability of the technology in the market; investments in physical machinery; technical assistance and training to upgrade operation and management skills; adequate infrastructure; and technological standards.[53]

Cambodia has made significant social and economic improvements in the last decade, as discussed in the previous section; however, the country still faces several challenges to take full advantage of the opportunities offered by digital technologies. This section discusses the findings from the first stakeholder consultation carried out in Cambodia in October 2019. It assesses the readiness of Cambodia in the "digitalisation journey", at both system and firm level. The discussion is focused on the capabilities and contextual factors needed for the diffusion and deployment of Industry 4.0 technologies.

50 Cirera, X. and Maloney, W. (2017). *Op. cit.*
51 Ibid.
52 Freeman, C. (1987). *Technology and Economic Performance: Lessons from Japan.* Pinter, London.
53 Cirera, X. and Maloney, W. (2017). *Op. cit.*

Stakeholders' insights are complemented with findings from the review of previous studies assessing Cambodia's innovation system and reports on the readiness of the country to adopt Industry 4.0 technologies.

4.2 Initial observations on Cambodia's Industry 4.0 readiness – contextual factors

A national innovation system involves three key functions: knowledge generation, knowledge diffusion and knowledge deployment. Technology adaptation and adoption rely mainly on the last two, that is, on the capabilities and contextual conditions that enable innovation actors to share, access and use new technologies. From a system perspective, barriers to diffusing and deploying technologies include: infrastructure gaps, a lack of standards, skills shortages and incomplete financial markets.

There have emerged different international efforts to assess and raise awareness of the factors and conditions needed to take advantage of digital technologies, namely, "digitalisation readiness". Table 4.1 presents a comparison of four innovation and digitalisation readiness indices for eight ASEAN countries where data is available. These composite indices measure different dimensions of the readiness to adopt digital technologies, such as: skills; the institutional framework; infrastructure; the use of technologies by business, government and people; and the business environment. Although these indices follow different methodologies, they share common indicators and provide useful information to assess countries.

Cambodia lags behind other ASEAN members in its readiness to adopt digital technologies. Internationally, the country is placed below the seventieth percentile in the four innovation and readiness indices analysed; meanwhile, in the ASEAN region the country ranks in last position.[54]

Table 4.1 Rankings of the ASEAN countries by their innovation and digitalisation readiness

Country	Global Innovation Index (GII)[1/] (out of 127 countries)	Readiness for the Future of Production Assessment[2/] (out of 100 countries)		Networked Readiness Index (NRI)[3/] (out of 139 countries)	Digital Adoption Index [4/] (out of 180 countries)
		Structure of production	Drivers of production		
Singapore	8	11	2	1	1
Malaysia	35	20	22	31	41
Viet Nam	42	48	53	79	91
Thailand	43	12	35	62	61
Brunei	71	N.A.	N.A.	N.A.	58
Philippines	54	28	66	77	101
Indonesia	85	38	59	73	109
Cambodia	98	81	91	109	123

1/ Captures five innovation inputs (institutions; human capital and research; infrastructure; market sophistication; and business sophistication) and two outputs (knowledge and technology; and creative).
2/ Comprises 59 indicators across drivers of production (technology and innovation; human capital; global trade and investment; institutional framework; sustainable resources; and demand environment) and structure of production components (complexity and scale).
3/ Captures performance in ten pillars: political and regulatory environment; business and innovation environment; infrastructure and digital content; affordability; skills; individual usage and government usage; and economic and social impacts.
4/ Simple average of three sub-indexes that capture the availability of digital technologies for business, people and government.
N.A. Data not available.
Source: Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation,* Ithaca, Fontainebleau and Geneva; World Bank (2016). *World Development Report 2016: Digital Dividends.* Washington, DC: International Bank for Reconstruction and Development/World Bank; World Economic Forum (2016b). *The Global Information Technology Report 2016.* Geneva; World Economic Forum (2018b). *Readiness for the Future of Production Report 2018.* Geneva.

54 Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation,* Ithaca, Fontainebleau and Geneva; World Economic Forum (2016b). *The Global Information Technology Report 2016.* Geneva; World Economic Forum (2018b). *Readiness for the Future of Production Report 2018.* Geneva.

The readiness of Cambodia's economy to adapt and adopt Industry 4.0 technologies was assessed based on a review of international innovation and digitalisation readiness reports; previous studies on Cambodia's innovation system and digitalisation; innovation indicators; and on consultations with local stakeholders.

Approximately forty stakeholders were consulted in order to gain a broad insight into the barriers and opportunities to the adaptation and adoption of Industry 4.0 technologies in Cambodia. Four consultation activities were conducted:

- Interviews with government officials, a representative from academia and stakeholders from international organisations (Appendix 3);
- Policy workshop with stakeholders from public bodies and research organisations (Appendix 4);
- Industry workshop with representatives from the private sector (Appendix 5);
- Visit to a garment factory.

4.2.1 Strengths and opportunities

Key strengths of Cambodia's innovation system to adapt and adopt Industry 4.0 include:

- Emerging initiatives from innovation actors;
- Growing economy and increasing FDI flows;
- Demographic dividend.

Key opportunities include:

- Technological spillovers from FDI;
- Diffusion of technologies through international collaboration;
- Increasing demand for high-value added goods.

Despite lagging behind in building the capabilities and the environment needed to reap the benefits from digital technologies, Cambodia shows some readiness strengths. There is a clear willingness among innovation actors to strengthen the country's production and innovation capabilities. Examples of initiatives in this direction include: the Skills Development Fund, the Entrepreneurship Development Fund, the T-ICT Development Policy and the Policy Framework for Cambodia's Digital Economy (in progress). In addition, the increasing interest in digital technologies is creating opportunities for adjustments in the curriculum of higher education institutions to address industry's changing needs.

A strong economy with increasing flows of foreign direct investment and several Special Economic Zones (SEZ) are relevant advantages that have the potential to generate technological spillovers in domestic firms. Established international collaboration and preferential access to international markets constitute additional potential channels for the diffusion of digital technologies.

Access to credit and investment capital is usually needed for the adoption of new technologies. The costs of technology deployment involve not only the price of technology acquisition but also the cost of the complementary investment and learning needed.[55] The local stakeholders consulted perceived constrained access to capital for local enterprises; however, indicators from previous reports suggest some progress in terms of access to credit and capital, particularly through micro-loans, joint ventures and strategic alliances.

Although there are several infrastructure gaps, Cambodia has wide coverage of the mobile phone infrastructure. A demographic dividend, increasing productivity and the capacity to attract and retain talent are strengths that are highlighted in international reports. Local stakeholders also highlighted the command of English by the skilled workforce. As demand for high-value added goods is growing and digital technologies are becoming cheaper and more widely used, opportunities are opening up for the creation of higher-skilled jobs so that the country can take advantage of its demographic dividend.

55 Hall, B.H. (2005). 'Innovation and diffusion". In Fagerberg, J., Mowery, D. and Nelso, R. *The Oxford Handbook of Innovation.* Oxford: Oxford University Press, pp. 459–484.

Table 4.2 summarises some of Cambodia's digitalisation readiness strengths, as highlighted in the international reports.

Table 4.2 Cambodia's digitalisation readiness strengths

Readiness strengths	Score or value	Rank /out of
Economic trends		
Foreign direct investment net inflows, % GDP	11.7	10/127
Infrastructure		
Mobile phone subscriptions/100 population	132.7	40/136
Education, skills and labour		
Country's capacity to attract and retain talent, 1–7 (best), perception	3.7	38/100
Growth rate of PPP$ GDP/worker, %	4.9	9/127
Access to investment capital and finance		
Domestic credit to private sector, % GDP	86.7	32/127
Microfinance gross loans, % GDP	7.5	1/127
Joint venture and strategic alliance deals/bn PPP$ GDP	0.1	25/127

Source: Cornell University, INSEAD, and WIPO (2017). *The Global Innovation Index 2017: Innovation Feeding the World*, Ithaca, Fontainebleau and Geneva; Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation,* Ithaca, Fontainebleau and Geneva; World Economic Forum (2016b). *The Global Information Technology Report 2016.* Geneva; World Economic Forum (2018b). *Readiness for the Future of Production Report 2018.* Geneva.

4.2.2 Weaknesses and threats

Key weaknesses of Cambodia's innovation system to adapt and adopt Industry 4.0 include:

- Limited basic and digital infrastructure;
- Inadequate institutional framework;
- Skills shortages.

Key threats include:

- Negative impacts of technology adoption on jobs;
- Competition from emerging and developed economies;
- Potential loss of preferential access to international markets.

Five key areas have been identified where improvements are needed to enable Cambodia to adapt and adopt Industry 4.0: i) basic and digital infrastructure; ii) institutional framework; iii) network linkages; iv) skills development; and v) innovation capabilities and access to knowledge.

Inadequate physical – electricity and transportation – and digital infrastructure is one of the key weaknesses of the national innovation system. According to a World Bank survey, around half of the manufacturing firms in Cambodia experience electrical outages.[56] The education infrastructure was also highlighted by local stakeholders as an area that needs improvements. An underdeveloped institutional framework that struggles to enforce existing norms and to protect intellectual property is another significant barrier faced by Cambodia in the adoption of digital technologies.

Interactions between academia and the private sector are perceived as limited by local stakeholders. This not only constrains the potential to diffuse the knowledge generated in research centres and universities but also limits the responsiveness of education to the skills needs of the industry.

Skills development is a structural challenge in

56 World Bank (2019a). *Cambodia – Enterprise Survey 2016.*

Cambodia, since low school attendance rates are linked to low returns to education.[57] A shortage of skilled technicians is an issue that has been highlighted in previous studies on Cambodia's national innovation system.[58] There are 38 public, 44 private and 21 NGO-managed technical and vocational education institutions in Cambodia.[59] However, the courses provided have little application to manufacturing. Most of the courses and enrolments focus on agriculture-related topics, languages and, to a lesser degree, basic technical skills: electricity, motor repair, air-conditioning repair and welding.[60]

Cambodia has 109 higher education institutions, 60% of which are private.[61] Enrolments in tertiary education, however, are relatively low in comparison with its ASEAN peers. In Cambodia, university graduates represent 4.8% of the population aged 25 years and older, while the ASEAN average is 12.9%.[62] Social sciences, business and management represent over 80% of the enrolments in higher education institutions.[63] Previous studies have highlighted the resulting limited generation of scientists and engineers.[64]

Universities perform limited innovation activities in Cambodia; examples of institutions engaged in R&D include: the Royal Academy of Cambodia, the Royal University of Phnom Penh, the Institute of Technology of Cambodia and the National Polytechnic Institute of Cambodia.

Investment in research and development (R&D) in Cambodia is relatively low in comparison to the ASEAN average, as Table 4.3 shows. Over 50% of the R&D performed in the country is financed by non-profit and international organisations, while the government and the private sector each contribute around one-fourth of the total R&D expenditure.[65]

Low investment levels are mirrored in the small number of human resources available to conduct R&D activities, and the consequently limited knowledge outputs, such as patents and scientific and technical journal articles. Nonetheless, the production of journal publications has significantly increased in recent decades.[66] Low R&D expertise also constrains local capabilities to adapt technologies to the local context.

Table 4.3 Selected research and development indicators, 2017 or latest year available

Indicator	Cambodia	ASEAN average*
Research and development expenditure (% of GDP)	0.12	0.70
Private sector share of total R&D expenditure (%)	19	45
R&D personnel per million inhabitants (FTE)	122.1	1,974.8
Total patent applications (residents and non-residents, per million population)	4	348
Scientific and technical journal articles (per million population)	7	412

*Data coverage: Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam.
Source: World Bank (2019b). *World Development Indicators.* Available at: https://datacatalog.worldbank.org/dataset/world-development-indicators; UNESCO. *UIS.Stat.* Available at: data.uis.unesco.org

57 UNDP Cambodia (2014). *Human capital dynamics and industrial transition in Cambodia.* Discussion Paper No. 11.
58 OECD (2013). *Op. cit.*; Royal Government of Cambodia (2013). *Op. cit.*
59 Cambodia Ministry of Labour and Vocational Training (2019). *Key Indicators – TVETMIS 2017-2018.* Available at: http://www.tvetmis.com/public/english/about.php
60 Royal Government of Cambodia (2013). *Cambodia's National Science and Technology Master Plan (2014–2020) for growth and quality of life;* Cambodia Ministry of Labour and Vocational Training (2019). *Technical and vocation education and training. Statistics. Academic year 2017–2018.*
61 Hayden, M. (2019). "Challenges to Higher Education in Laos and Cambodia". *International Higher Education,* (97), pp. 20–21.
62 UNESCO. *UIS.Stat.* Available at: data.uis.unesco.org
63 OECD (2013). "Cambodia: innovation profile". In *Innovation in Southeast Asia,* Paris: OECD Publishing.
64 OECD (2013). *Op. cit.*; Royal Government of Cambodia (2013). *Op. cit.*
65 UNESCO (2019). *UIS.Stat.* Available at: data.uis.unesco.org
66 Royal Government of Cambodia (2013). *Op. cit.*

International reports stress the limited role of technology in driving Cambodia's economic growth. Knowledge-intensive employment represents only 5.3% of total employment; and even though the presence of foreign companies represents an opportunity for technological spillovers, technology imports seem limited. High-tech imports represent 2.7% of total trade, which are among the lowest levels internationally.

As discussed in Section 2, the main concerns around Industry 4.0 are related to the potential negative impacts of the adoption of these technologies. In Cambodia, sources of concern include: job losses in occupations involving repetitive tasks; potential negative effects on health; competition from developed countries; cyber threats; and increasing dependence on a high-skilled foreign labour force. Additional threats to the national innovation system include increasing competition from emerging economies and the loss of comparative advantages due to a reduction in the prices of garment products and increases in the cost of raw materials. The potential loss of preferential treatment in international markets, in particular, may reduce the flows of FDI and make it more difficult to import technology to the country.

Table 4.4 summarises some of Cambodia's weaknesses in relation to digitalisation readiness, as highlighted in the international reports.

Table 4.4 Cambodia's digitalisation readiness weaknesses

Readiness weaknesses	Score or value	Rank /out of
Infrastructure		
Transport infrastructure, 0–100 (best)[1/]	26.8	95/100
Electricity infrastructure, 0–100 (best)[2/]	20.8	99/100
Internet users, % population	25.6	91/100
Education, skills and labour		
Mean years of schooling	4.7	98/100
Quality of vocational training, 1–7 (best), perception	3.3	92/100
Pupil-to-teacher ratio in primary education	45.5	95/100
Expenditure on education, % GDP	1.9	117/127
Institutional framework		
Regulatory efficiency, 0–100 (best)[3/]	57.5	92/100
Corruption perceptions index, 0–100 (best)	21	100/100
Rule of law 2.5–2.0 (best), perception	-1.1	99/100
Intellectual property protection, 1–7 (best), perception	2.8	131/136
Number of procedures to enforce a contract	44	122/136
Number of days to start a business	87	136/136
Innovation capabilities and access to knowledge		
Knowledge-intensive employment, %	5.3	107/127
High-tech imports less re-imports, % total trade	2.7	125/127
Impact of ICTs on access to basic services, 1–7 (best), perception	3.3	120/136
Usage of ICT and government efficiency, 1–7 (best), perception	3.2	120/136

1/ Composite index of eight indicators that measure roads, railroads, air transport and water transport infrastructure.
2/ Composite index of two indicators that measure the electrification rate and electric power transmission and distribution losses.
3/ Average of score of three components from the Index of Economic Freedom: business, labour and monetary freedom.
Source: Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation*, Ithaca, Fontainebleau and Geneva; World Economic Forum (2016b). *The Global Information Technology Report 2016*. Geneva; World Economic Forum (2018b). *Readiness for the Future of Production Report 2018*. Geneva.

Table 4.5 presents a summary of the strengths, weaknesses, opportunities and threats discussed in this section. It builds on both stakeholder consultations and the literature review.

Table 4.5 Strengths, weaknesses, opportunities and threats analysis of Cambodia's innovation system

Strengths	Weaknesses
Economic trends - Growing economy with increasing trade and foreign direct investment (FDI) flows. **Business support** - Increasing support for SMEs, e.g. Biz info system and the SMEs bank initiative. **Infrastructure** - University initiatives of labs and research centres. **Education, skills and labour** - Demographic dividend, people under 35 years of age represents approx. 70% of the population; - Wide use of smartphones among the population; - Knowledge of English; - Competitive labour costs. **Institutional framework** - Government initiatives are emerging to strengthen the capabilities of the national innovation system, e.g. the Skills Development Fund, the Entrepreneurship Development Fund and the e-government policy; - Special Economic Zones; - Political stability. **International collaboration** - Partnerships between local stakeholders and international organisations; - Students and faculty exchanges with foreign universities. **Markets** - Access to markets through free trade agreements with ASEAN+3 and other countries in different regions.	**Infrastructure** - Limited infrastructure, equipment and human resources in higher education institutions; - Limited and unstable power supply infrastructure; - Costly Internet and limited coverage area. - Inadequate road connections. **Education, skills and labour** - Outdated education programmes; - Limited public and private investment in education and training; - Lack of technology-related jobs; - Shortage of semi-skilled and highly skilled labour. **Innovation capabilities and access to knowledge** - Limited R&D investment due to budget constraints; - Limited capacity regarding data privacy and security; - Low interaction between different innovation actors; - Low technological absorptive capacity in most of the SMEs; - High dependence on foreign technology; - Lack of awareness of the benefits of new technologies. **Access to investment capital and finance** - Constrained access to capital for local enterprises. **Institutional framework** - Low intellectual property protection; - Inadequate compliance with standards; - Need for better coordination between ministries; - High transaction costs; - Complicated tax and export procedures.

Opportunities	Threats
Education, skills and labour • Because of the pressure to catch up with new technologies, the customised curriculum of public education into STEM may be developed and adapted; • Skills and knowledge transfer through FDI; • Growing demand for technicians and, increasingly, for STEM graduates. **Innovation capabilities and access to knowledge** • International focus on using technology for development (SDGs); • Reductions in production costs and increase in productivity through technology adoption. **International collaboration** • Long-term cooperation with international partners (university – international agencies); • Financial support from Australia to ASEAN member states on capacity-building in digital technologies; • Worldwide technology integration. **Markets** • Shifting in production chains during trade war may increase technology transfer; • Growing demand for high-value-added goods.	**Uncertain impacts of emerging technologies** • Cyber threats; • Disruptive technology from developed countries may take over local innovation; • Job losses in occupations involving repetitive tasks; • Negative effects of technology adoption on health; • Big companies may disrupt local businesses or even eradicate local infant industries; • Adoption of Industry 4.0 technologies may require extensive talented labour from outside. **Education, skills and labour** • Increasing wages; • Intensifying global competition for talent. **Business support** • Traditional business fails. **Markets** • Growing competition of emerging economies; • Rising cost of raw materials; • Decreasing price of finished products, e.g. garments; • Potential loss of preferential treatment in international trade.

Source: Policy Links with information collected from a workshop conducted with government and academia stakeholders in Cambodia, 9 October 2019; Australian Aid – The World Bank Group (2015). *Cambodian agriculture in transition: opportunities and risks*. Economic and Sector Work, Report No. 96308-KH. The International Bank for Reconstruction and Development / The World Bank; JICA – Cambodia Ministry of Industry and Handicraft (2015). *Project for strategic strengthening of Small and Medium Enterprise (SME) Support System*; OECD (2013). "Cambodia: innovation profile". In *Innovation in Southeast Asia*, Paris: OECD Publishing; Chhem, R., et. Al. (2019) Industry 4.0: Prospects and Challenges for Cambodia's Manufacturing Sector. Policy Brief. CDRI.; Royal Government of Cambodia (2013). *Cambodia's National Science and Technology Master Plan (2014–2020) for growth and quality of life*; UNDP Cambodia (2014). *Human Capital Dynamics and Industrial Transition in Cambodia*. UNDP Cambodia.

4.3 Firm-level barriers and opportunities

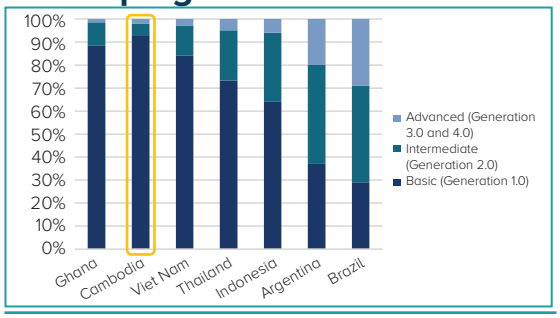
Technology adaptation and adoption in Cambodia will need to overcome some key barriers at firm level, including: a lack of awareness of digital technologies and their benefits; the high cost perception of technologies; aversion to the use of new technologies; skills gaps; and access to finance.

Opportunities at firm level include: energy efficiency; enhanced capital utilisation; improved supply chain management; participation in regional supply chains; and increased value-added.

A workshop with local stakeholders from the private sector was conducted to gain insights into the trends, drivers, opportunities and barriers to the adaptation and adoption of Industry 4.0 in Cambodia.

The stakeholders consulted perceive that a small number of firms in Cambodia (~1-3%) have adopted digital technologies at an advanced level, while most of the companies show a basic level of technology adoption (~90–96%).[67] As Figure 4.1 illustrates, although these perceptions speak of low levels of adoption of advanced technologies in Cambodia, similar rates are observed in other developing countries, particularly ASEAN neighbours such as Thailand and Viet Nam.

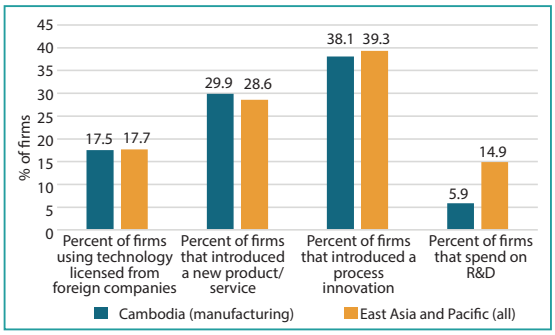
Figure 4.1 Adoption of advanced technologies is limited in Cambodia, as in other developing countries



Note: In Cambodia and Indonesia the categories used were low, moderate and advanced technology adoption.
Source: Policy Links based on information from focus group discussions conducted with industry stakeholders (Cambodia and Indonesia); and UNIDO (2019b). *Industrial Development Report 2020. Industrializing in the digital age. Overview.* Vienna.

Innovation activities performed by manufacturing firms in Cambodia rarely involve research and development; however, the proportion of firms engaged in product and process innovation is similar to the East Asia and Pacific average (Figure 4.2).

Figure 4.2 Firms' innovation in Cambodia rarely involves R&D



Source: World Bank (2019e). *Cambodia – Enterprise Survey 2016*

Overall, the adoption of Industry 4.0 technologies is perceived as a process whereby some fundamental barriers will need to be overcome in terms of infrastructure and skills. At firm level, barriers to adopting Industry 4.0 include: a lack of awareness of digital technologies and their benefits; the high cost perception of technologies; aversion to the use of new technologies; skills gaps; limited access to training and technical assistance; and constrained access to finance.

According to the World Bank Enterprise survey, around one-fifth of manufacturing firms in Cambodia consider an "inadequately educated workforce" to be the biggest challenge of the business environment.[68] Although domestic credit to the private sector represents 86.7% of GDP,[69] firms seem to be struggling to use bank finance for their investments. Only 7.7% of the

67 Advanced – firms use digital technologies across various operations; digital technologies used by the firms are at least as advanced as their competitors; actively engaged in innovation and R&D. Intermediate – firms have started to use some advanced digital technologies in specific operations but some competitors are ahead; they are motivated to engage in innovation but constrained by limited resources. Basic – firms perform many activities through manual work (and paper-based processes) without the use of digital tools; they lack the resources to engage in innovation.
68 World Bank (2019e). *Op. cit.*
69 Cornell University, INSEAD, and WIPO (2019). *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation,* Ithaca, Fontainebleau and Geneva.

manufacturing firms in Cambodia use banks to finance their investments, a percentage below the East Asia and Pacific average (14.6%).[70]

Box 4.1 summarises the key barriers perceived by firms, which are mainly related to the diffusion and deployment of new technologies. The box captures the perceptions of the stakeholders consulted, which have been complemented with insights from previous studies.

Box 4.1 Barriers to adapting and adopting industry 4.0 technologies in Cambodia – firms' perceptions

Barriers to developing new technologies

- Limited local R&D activity;
- Low investment in R&D.

Barriers to diffusing new technologies

- Lack of awareness of digital technologies and their benefits;
- High cost perception of technologies;
- Limited enforcement of intellectual property laws;
- Limited capacity regarding data privacy and security.

Barriers to deploying new technologies

- Lack of training facilities and courses;
- Competitive cost of labour force;
- Lack of technical assistance;
- Limited maintenance services;
- Fear of adopting new technology;
- Shortage of semi-skilled and high-skilled workers;
- High staff turnover;
- Costly and low-quality raw materials.

Contextual enablers

- Limited, costly and unstable electricity supply;
- Constrained access to capital and credit for local enterprises;
- Regional competitors;
- Small domestic market;
- FDI concentrated on buyer-driven global value chains.

Sources: Industry workshop in Cambodia, 10 October 2019; Japan International Cooperation Agency (2015). *Project for Strategic Strengthening of Small and Medium Enterprise (SME) Support System.* Kingdom of Cambodia. Ministry of Industry and Handicraft. JICA; World Bank (2019e). *Cambodia – Enterprise Survey 2016.* Available at: https://datacatalog.worldbank.org/dataset/cambodia-enterprise-survey-2016

70 World Bank (2019e). *Op. cit.*

Garments, footwear and agri-food are the most important manufacturing industries in Cambodia. Significant participation by foreign companies, which tend to perform a larger amount of innovation activities than domestic ones,[71] is found in these industries. However, these firms are part of buyer-driven global value chains. The power disparity between buyers and suppliers limits the freedom of manufacturing companies to adopt new technologies; however, it also drives technology changes within firms, as a company visit illustrated (Box 4.2).

Box 4.2 Technology adoption in the garment sector: insights from a company visit

The team visited a Taiwanese garment company that began operations in Cambodia in 2007. It has two factories in Cambodia and one located in China. In addition, it owns two design rooms, one located in Taiwan Province of China and the other in China.

Since garments constitute a buyer-driven supply chain, the adoption of Industry 4.0 technologies has been driven mainly by the firm's international buyers. Before adopting new technologies in the factories located in Cambodia, managers test technologies in their plant in China, which is smaller. Lower digital literacy among Cambodian workers is a barrier that was reported in the adoption of new technologies.

The adoption of new technologies has meant changes in the tasks performed by workers. The firm has responded to these changes by providing training so that workers can perform new tasks and remain in the company.

Training is also highly influenced by buyers, particularly in areas such as quality control and sewing. Key sources of training highlighted by the company include: the Garment Manufacturers Association in Cambodia (GMAC), the International Labour Organisation (ILO) and a third-party inspection unit. Although the company struggles to find local people to perform managerial roles, it did not report problems hiring skilled machine operators.

Other issues mentioned by the managers include: electricity supply (although this seems to be improving); import processing (which could be sped up); and opportunities to more efficiently integrate into regional supply chains with Thailand, Viet Nam and China.

Source: Company visit.

The private sector stakeholders consulted perceive that Industry 4.0 technologies represent an opportunity to boost productivity, reduce costs and diversify the economy. Specific opportunity areas mentioned during the consultations include:

- Energy management;
- Renewable energy production;
- Predictive maintenance;
- Traceability;
- Inventory and distribution management services;
- Increasing value added from food processing;
- Consumer feedback through data analytics;
- Opportunities to work with international clients to support technology transfer;
- The creation of more sophisticated tasks (and better-paid jobs) for local employees through digital technology adoption;
- Opportunities to more efficiently integrate into regional supply chains with Thailand, Viet Nam and China.

71 World Bank (2019e). *Op. cit.*

4.4 Conclusions

Adaptation and adoption of Industry 4.0 in Cambodia will need to overcome barriers at both national innovation system and firm level. At system level, five key areas were identified where improvements are needed: i) basic and digital infrastructure; ii) institutional framework; iii) network linkages; iv) skills development; and v) innovation capabilities and access to knowledge. At firm level, the key barriers include: a lack of awareness of digital technologies and their benefits; the high cost perception of technologies; aversion to the use of new technologies; skills gaps; limited access to training and technical assistance; and constrained access to finance.

Although it faces several challenges, Cambodia's innovation system also shows some strengths, including a growing economy with increasing FDI flows; a demographic dividend; and established international collaboration. In addition, emerging efforts from different innovation actors – government, HEIs, non-profit and private organisations – to enhance their capabilities and increase their interactions are creating opportunities to leverage technological spillovers from FDI and international collaboration for the adoption of Industry 4.0 technologies.

A demographic dividend represents both an opportunity and a challenge for a country. A young and increasingly educated population means a productive labour force but also increasing demands for more and better jobs. Policies promoting technology adoption have a role to play in addressing this demand. As digital technologies are becoming cheaper and more widely used, opportunities are opening up for the creation of higher-skilled jobs so that the country can take advantage of its demographic dividend. Policy interventions also play a role in preventing and reducing the potential negative impacts of technology adoption.

Although this review and consultations provide useful cross-sectoral insights into Cambodia's readiness to adapt and adopt Industry 4.0 technologies, in-depth industry-specific analysis and firm-level insights will be needed in the next stages of the project in order to design mechanisms that can contribute to the roll-out of Industry 4.0 in Cambodia.

SECTION 5
THEMATIC POLICY PRIORITIES AND SUGGESTED NEXT STEPS

Key points of this section

- The Royal Government of Cambodia is making significant efforts to build the capabilities and the environment needed to reap the benefits of digital technologies, such as the Policy Framework for Cambodia's Digital Economy that is currently being developed.
- An Industry 4.0-specific strategy that addresses the particular challenges of the manufacturing sector would complement these efforts.
- Two broad priority thematic areas were identified during the scoping phase of this project:
  - *Industry 4.0 roll-out* (focus of the subsequent stages of the LTA). Technology transfer and deployment; technology awareness and diffusion; technology development and importing.
  - *Contextual enablers*. Policy, finance, education, regulations and industrial infrastructure.

5.1 Introduction

This section discusses the key thematic policy priorities identified to support the adaptation and adoption of Industry 4.0 technologies in Cambodia, based on the findings from previous sections. The section first briefly reviews the relevant policies of the Royal Government of Cambodia (RGC). It then suggests next steps to ensure that the work programme of the Long-Term Agreement (LTA) is as useful as possible to inform the policy agenda of the RGC, as well as UNDP's programmatic support on the topic of Industry 4.0.

5.2 Cambodia's industrial and innovation policy landscape – a brief overview

The RGC's vision is to promote economic inclusion and environmental sustainability to ensure that Cambodia becomes an upper-middle-income country by 2030 and a high-income country by 2050. In order to materialise this vision, the government is implementing and developing a set of mid- and long-term policies, some of which have incorporated digital technologies as key drivers of growth and development.

The "Rectangular Strategy-Phase IV" is the overarching socio-economic policy agenda of the "Political Platform of the Royal Government of the Six Legislature of the National Assembly".[72] The aim of the Rectangular Strategy is to achieve four strategic goals:

i. Ensuring sustainable economic growth of around 7% per annum;

ii. Creating more and better jobs;

72 Royal Government of Cambodia (2018). *"Rectangular Strategy" for Growth, Employment, Equity and Efficiency: Building the Foundation Toward Realizing the Cambodia Vision 2050 – Phase IV of the Royal Government of Cambodia of the Sixth Legislature of the National Assembly."*

iii. Reducing poverty to below 10%; and

iv. Strengthening the capacity and governance of public institutions.

In order to achieve the above goals, the strategy focuses on four priority areas (roads, water, electricity and people) and four strategic rectangles:

- Rectangle 1 – Human resource development (quality of education, vocational training, public health, gender equality);
- Rectangle 2 – Economic diversification (improving logistics, transport and digital connectivity);
- Rectangle 3 – Promotion of private sector development and employment (job market development; promotion of SMEs; public–private partnership); and
- Rectangle 4 – Inclusive and sustainable development (agriculture and rural development; sustainable management of natural and cultural resources; environmental sustainability).

In the Rectangular Strategy, the RGC has placed the "Digital Economy" and the "Industry Revolution 4.0" as key drivers of economic diversification (Rectangle 2).

In a systemic effort to guide the implementation of the Rectangular Strategy, an industrial development policy, a national policy on technical and vocational training, a long-term science and technology policy and a telecommunications and information and communication technologies (ICT) development policy were also developed (Box 5.1).

Box 5.1 Cambodia's industrial and innovation policy landscape – brief overview

The Industrial Development Policy 2015–2025 (IDP) is led by the vision that it is necessary to transform Cambodia's industrial structure into a more diversified and skills-driven industry by 2025. To achieve this vision, the IDP has set three targets:

- Increasing the GDP share of the industrial sector to 30% in 2025 from 24.1% of GDP in 2013, and the manufacturing share growing from 15.5% in 2013 to 20% in 2025;
- Increasing the export of manufacturing products (non-textile products) to 15% by 2025; increasing exports of processed agricultural products to 12% of all exports by 2025; and exporting new products;
- Strengthening and promoting the official registration of SMEs, with a 2025 target of 80%–95% of SMEs being officially registered, of which 50% to 70% should have accurate accounts and balance sheets.

Priority sectors mentioned in the industrial strategy include: agri-food; garments; pharmaceutical and medical equipment production; construction materials, packaging equipment for export; furniture manufacturing; industrial equipment; information and communications technology (ICT); energy; and green technology.

The National Technical and Vocational Education and Training (TVET) Policy 2017–2025 is Cambodia's main instrument to strengthen the country's human resources. The policy involves four goals:

- Improve TVET quality to meet national and international market demand;
- Increase equitable access to TVET;
- Promote public–private partnerships (PPPs) and aggregate stakeholder resources to support sustainable development of the TVET system; and

- Improve governance of the TVET system.

Cambodia has also implemented its first national medium- and long-term science and technology policy. The National Science and Technology Master Plan 2014–2020 focuses on three priority sectors (agriculture, "primary industries" and information and communication technologies). It involves four strategies:

- S&T development based on human resources;
- Establishment of Cambodia-driven S&T cooperation network;
- Discovery of successful S&T cases and the accumulation of outcomes (identifying and disseminating successful S&T cases); and
- Selection and concentration of national S&T resources.

In order to address the infrastructure, regulatory and skills gaps in telecommunications and ICT, the RGC has developed the T-ICT Development Policy 2020, which involves three strategies:

- Strengthening the foundations for T-ICT development (regulatory framework, infrastructure, T-ICT literacy and skills development);
- Enhancing ICT security and developing T-ICT industry; and
- Promoting ICT applications in government; commerce; climate change adaptation and mitigation; and disaster management.

Sources: Royal Government of Cambodia (2015). *Cambodia Industrial Development Policy 2015–2025;* ADB (2018b). *Cambodia's New Technical and Vocational Education and Training Policy.* ADB Briefs. No. 89; Royal Government of Cambodia (2013). *Cambodia's National Science and Technology Master Plan (2014–2020) for growth and quality of life*; Royal Government of Cambodia (2016). *I-ICT Development Policy 2020. Toward ICT Connectedness and Readiness.*

In addition, the RGC is currently developing the Policy Framework for Cambodia's Digital Economy, the aim of which is to create an enabling environment for a "digital economy", defined as an economy where a significant "part of the output is derived from digital technologies with a business model based on digital goods and services".[73]

This framework covers five strategic areas: digital infrastructure; digital government; digital business; digital literacy and capability; and digital trustworthiness. The framework is led by the Ministry of Economy and Finance, the Supreme National Economic Council and the Ministry of Posts and Telecommunications.

Other key government actors involved in strengthening the capabilities and the enabling environment for the diffusion and deployment of technologies include:

- The Ministry of Education, Youth and Sport (MOEYS), which is responsible for the provision and management of education.[74]
- The Ministry of Labour and Vocational Training (MLTV), which is responsible for technical and vocational education and training (TVET).[75]
- The National Science and Technology Council, established in 2014, which is an advisory entity responsible for informing the science and technology policy.[76]

73 Kong, M (2019). *Long-term Policy Framework for Cambodia's Digital Economy.* Cambodia's Digital Economy Working Group.
74 Royal Government of Cambodia (2013). *Op. cit.*
75 Ibid.
76 Chhem, R., et al. (2019). Industry 4.0: Prospects and Challenges for Cambodia's Manufacturing Sector. Policy Brief. CRDI.

- The Ministry of Planning (MOP), through the General Secretariat of Science and Technology Council (GSST), which is responsible for the development of science and technology policies and for the coordination of efforts across the government. The MOP also oversees the National Institute of Statistics (NIS), which provides data in areas such as socio-demographics, economy and industry.[77]
- The Ministry of Industry and Handicraft (MIH), which is responsible for policies promoting industry. MIH-affiliated organisations include:
  - The General Department of Industry (GDI), which is in charge of the industrial normative framework and policies. It is responsible for industrial patents, standards, utility modes, industrial designs and licences. The GDI oversees the departments of Technique, Science and Technology; the Department of Industrial Property; and the National Productivity Centre.
  - The Institute of Standards of Cambodia (ISC), which is responsible for policies, registration, education and management of Cambodia's industrial standards.
  - The National Metrology Centre, which is responsible for promoting the use of measurement standards in industry.[78]

5.3 Recent progress and the challenges that lie ahead

Cambodia has made significant economic and social progress in the last two decades, the economy is growing at rates above 7% and poverty has more than halved, as discussed in Section 3. This progress has also meant improvements in the conditions needed for the adoption of Industry 4.0 technologies. The implementation of the T-ICT Development Policy 2020 has resulted in substantial investments in telecommunication infrastructure and expanded access to telecommunication services. Cambodia has a very high mobile Internet penetration (over 100%), and Internet penetration has more than tripled in the last five years.[79]

Although the Cambodian population is increasingly using digital technologies, the adoption of these technologies by companies is still limited.[80] The services sector reveals the most significant progress in the adoption of digital technologies; however, the extent to which e-commerce is being used is lower than in other ASEAN countries.[81]

Cambodia's manufacturing has increased its contribution to the economy over the last couple of decades, mainly driven by the garment and food-processing industries. Although these are labour-intensive sectors, more sophisticated industries are emerging in the country, including: the production of bicycles, electrical parts and automobile components.[82] In recent years an increase in knowledge-intensive jobs has been observed, with significant positive effects on wages. Average real wages grew by over 54% between 2009 and 2015.[83] The adoption of Industry 4.0 technologies by manufacturing companies has the potential to boost the growth of knowledge-intensive jobs and contribute to the diversification of manufacturing exports, a target of the Industrial Development Policy 2015–2025.

The National Technical and Vocational Education and Training Policy 2017–2025 and related programmes, such as the Skills Development Fund, represent significant efforts to address skills gaps; however, recent assessments and perceptions of the local stakeholders consulted suggest that ICT and other technical skills are areas that may need further development.[84] Occupations that show significant shortages, in addition to ICT professionals, include: mechanical engineers; electronic engineers; process control technicians; product and garment designers; machinery technicians; and welders.[85]

77 Royal Government of Cambodia (2013). *Op. cit.*
78 MIH (2019). *Departments*. Available at: http://www.mih.gov.kh/
79 Telecommunication regulator of Cambodia (2020). Statistics. Available at: https://www.trc.gov.kh/
80 UNCTAD (2017a). *Cambodia Rapid eTrade Readiness Assessment*. United Nations.
81 UNCTAD (2017a). *Op. cit.*
82 ADB (2018a). *Asian Development Outlook 2018: How Technology Affects Jobs*. ADB, April 2018. https://www.adb.org/publications/asian-development-outlook-2018-how-technology-affects-jobs
83 Cunningham, W. and Hollweg, Claire (2019). Cambodia's future jobs: Linking to the economy of tomorrow. World Bank Group. Korea-World Bank Partnership Facility.
84 National Employment Agency (2020). *Cambodia Job Outlook 2018*.
85 Ibid.

5.4 Thematic policy priorities identified during the scoping study

As discussed throughout this report, there is growing international agreement about the potential of Industry 4.0, defined as the convergence of digital technologies and manufacturing industries, to deliver improvements for both firms and countries.

A number of countries have implemented initiatives aimed at reaping the benefits of Industry 4.0; however, it is becoming increasingly clear that the full benefits of innovation only materialise when new knowledge and technologies are diffused and applied by firms. Yet, multiple challenges and failures limit technology diffusion – and these affect SMEs, in particular, because of their weak "absorptive capacity".

Two broad priority thematic areas were identified during the scoping phase of this project: i) Industry 4.0 Roll-out and ii) Contextual enablers. These form the basis of the roadmap in Annex 1.

5.4.1 Industry 4.0 roll-out / technology transfer (adaptation and adoption)

The Industry 4.0 roll-out involves activities to address the barriers identified that are hindering technology adaptation and adoption in general, and the roll-out of Industry 4.0 in particular, across three key areas, which will be the focus of subsequent stages of the LTA:

- ***Technology transfer and deployment.*** The adoption of new technologies involves a complex process of organisational adaptation beyond the acquisition of technology, including cultural, production and management transformations. Thus, the successful adoption of technologies may require a wide range of support services, such as workforce training, technical and business advice. The need for these services in Cambodia was highlighted by the stakeholders consulted.
- ***Technology awareness and diffusion.*** The decision to adopt new technologies depends on the perceived balance between the benefits and costs involved in this process. Industry networks, technology demonstration facilities and digital awareness activities allow firms to exchange best practices and to test new technologies at meaningful scales, thus reducing uncertainty about the benefits and costs of technology adoption. A lack of awareness of digital technologies and their benefits, and a high cost perception of technologies, were factors identified as barriers to technology adoption from the stakeholders' consultation. These barriers could be addressed through industry networks, technology demonstration and digital awareness activities.
- ***Technology development and importing.*** Once a feasible technology has been identified and selected, the next stage is the actual acquisition. Access to technologies depends on the availability and affordability of the actual technology and related services (e.g. maintenance, repair and training). Technologies can be developed nationally or imported. In both cases, R&D capabilities are relevant for developing or adapting new technologies to the local context. In addition, firms may need to overcome barriers to import technology. In Cambodia, scarce R&D outputs and limited imports of high technology goods were identified.

5.4.2 Contextual enablers

Technology adaptation and adoption can be understood as a multi-level process that involves overcoming barriers at both firm and national system level. At system level, *contextual enablers* involve a set of framework conditions such as infrastructure, finance, education and the institutional landscape. Although business support services may be developed in the short term, the development of contextual enablers is a long-term process.

The Royal Government of Cambodia is making significant efforts to improve innovation contextual enablers, as discussed in this report; however, there are still gaps that may need to be addressed to reap the benefits of Industry 4.0, including:

- ***Policy.*** RGC has an important role to play in facilitating technology adoption and avoiding the widening of existing inequalities. Although significant effort is already being

made, coordination between key actors is an opportunity to increase the effectiveness of existing initiatives and those about to be implemented, such as the "Digital Economy Policy Framework". Continuing efforts to strengthen policy delivery capabilities will also be needed.

- ***Finance.*** Easy access to credit and investment capital is needed to cover the costs of technology adaptation and adoption, which include not only the price of technology acquisition but also the cost of complementary investment and learning needed to use new technologies and to reconfigure production and management systems. Although there seems to be some easiness accessing credit and capital in Cambodia, particularly through microloans, joint ventures and strategic alliances, only a small proportion of firms are using finance to cover their investments.
- ***Education.*** Increasing the coverage and quality of the formal education and TVET systems are recognised challenges in Cambodia. Technology adoption will need to narrow the skills gaps at firm level and to address skills shortages at system level. Skills development and technology adoption also have the potential to create opportunities to take advantage of Cambodia's demographic dividend.
- ***Regulations.*** Adequate enforcement of intellectual property laws and the availability and compliance of standards constitute important enablers of technology adoption. These "traditional" enablers, perceived as areas for improvement in Cambodia, will need to be complemented by responsive regulation to address the safety, security and privacy concerns surrounding the integration of digital technologies into physical systems.
- ***Industrial infrastructure.*** Basic and digital infrastructure are essential conditions in order to take advantage of digital technologies. Although improvements have been observed in this area in Cambodia, there are still significant gaps in electricity supply and broadband coverage.

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ANNEXES

Annex 1: Outline roadmap for the roll-out of Industry 4.0

This annex presents an outline roadmap for the roll-out of Industry 4.0 in Cambodia. At this stage, the roadmap does not constitute a full implementation plan; nor does it include detailed activities, responsibilities or the resources required for implementation.

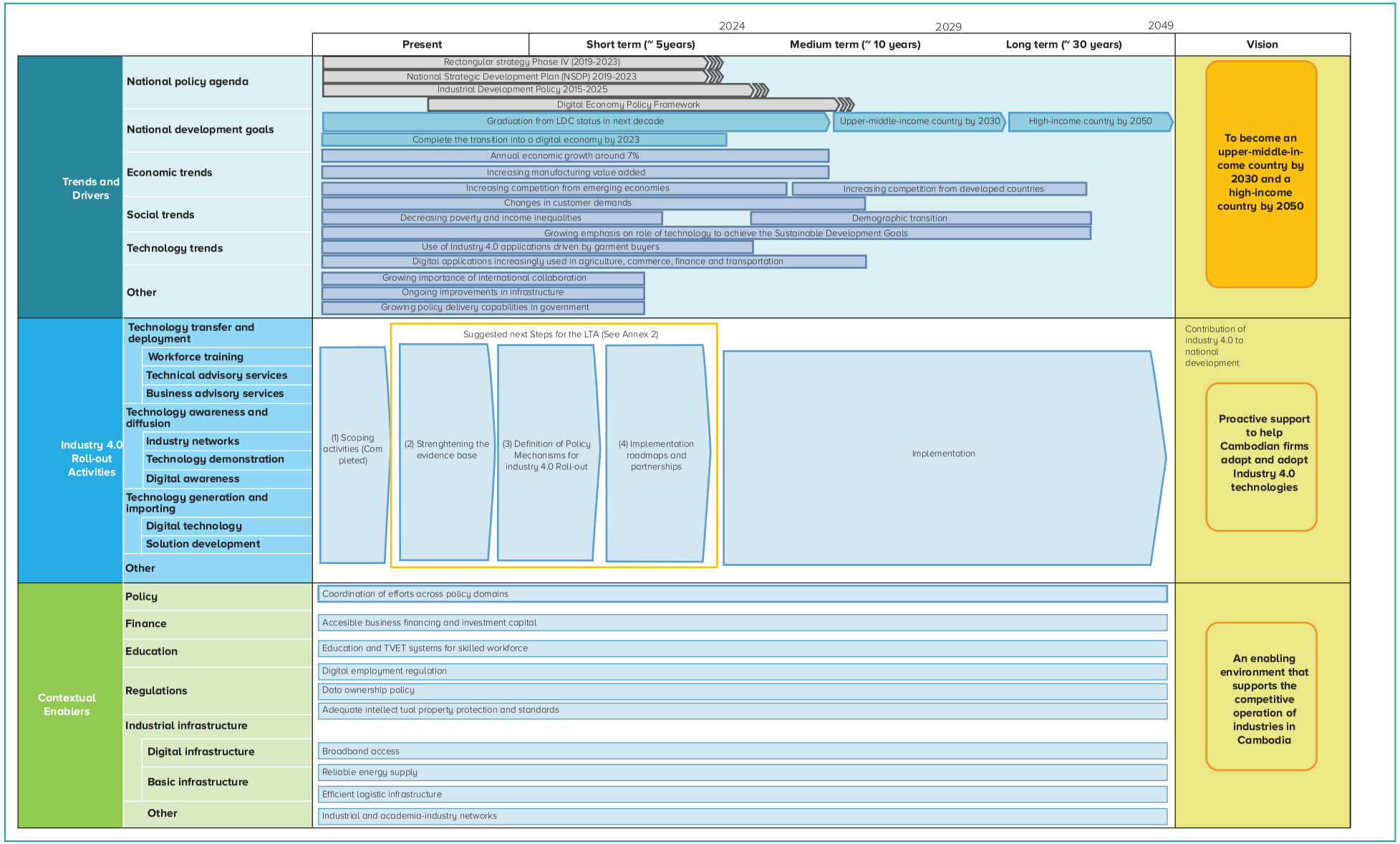
The roadmap does, however, clearly identify key policy areas that are relevant for the roll-out of Industry 4.0, and it defines the relationship between them, based on the findings of this scoping stage of the project. Tasks for the subsequent stages of the project are suggested based on the evidence gaps identified.

The structure of the roadmap is as follows:

- **Vision.** Cambodia's vision to become an upper-middle-income country by 2030 and a high-income country by 2050 drives the overall roadmap structure. The potential contribution of Industry 4.0 to national objectives is to create opportunities to diversify the economy and increase the productivity and competitiveness of Cambodia's manufacturing firms. In addition, the availability of Industry 4.0 technologies, and the related capacity-building, is expected to have effects in other sectors of the economy.
- **Time frame.** This is defined based on existing national policy agenda and development goals: present, short term (~ 5 years), medium term (~ 10 years) and long term (~ 30 years).
- **Trends and drivers.** A broad overview of the main agents of change in Cambodia's economy and society.
- **Activities for the roll-out of Industry 4.0 in Cambodia.** Specific activities necessary for the roll-out of Industry 4.0, to address the barriers identified in Section 4. These activities are discussed further in Annex 2.
- **Contextual enablers.** Broader factors that underpin Cambodia's competitiveness as an industrial location, which require long-term policy action.

Based on the outputs of the subsequent stages of the LTA, the roadmap could be completed and used as a simple but highly structured communication device to support the activities and strategies of both UNDP and the Royal Government of Cambodia.

Figure A1.1 Roadmap for the Roll-out of Industry 4.0 in Cambodia



Annex 2: Programming recommendations for UNDP

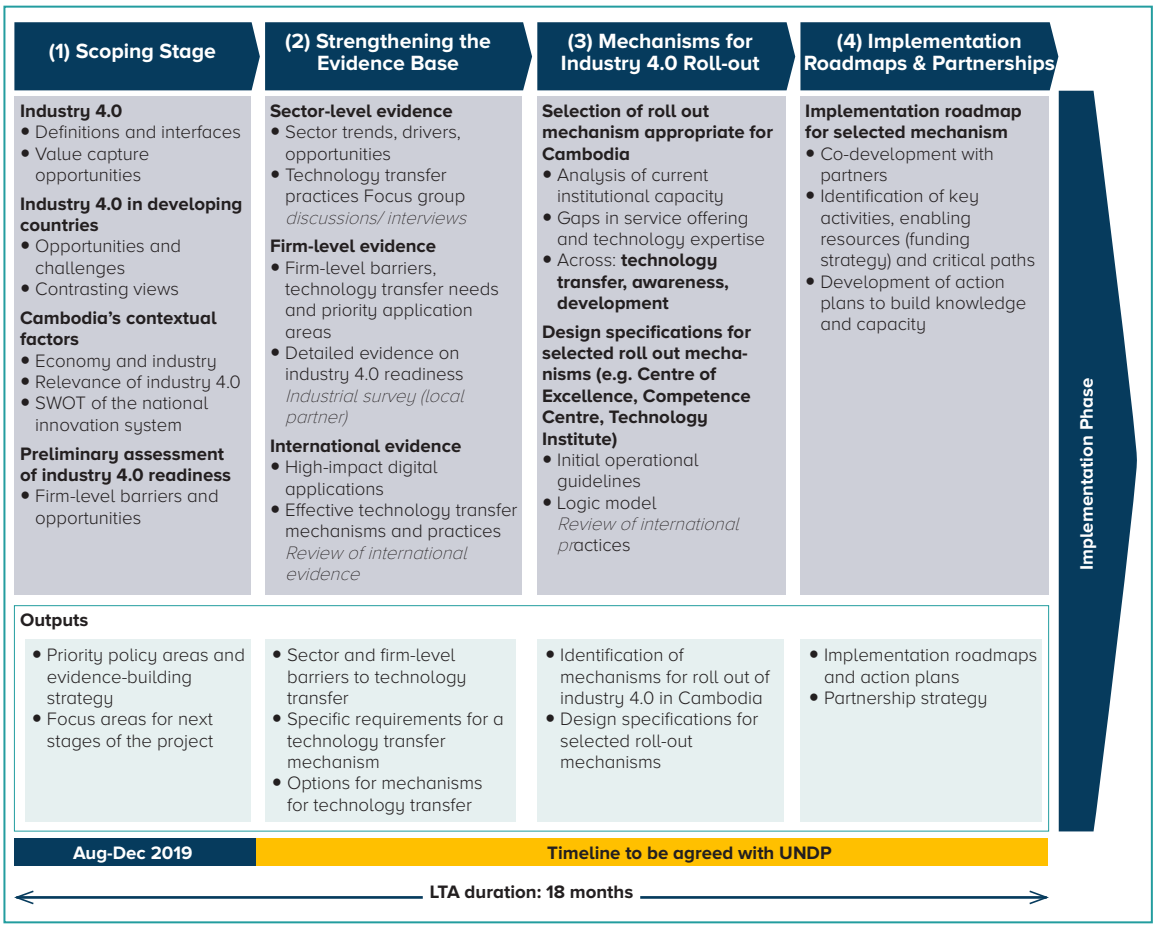
This annex suggests next steps for the LTA and discusses thematic areas in which UNDP could support the Royal Government of Cambodia (RGC) to achieve the roll-out of Industry 4.0 in Cambodia.

A2. 1 Suggested next steps for the LTA

Based on the evidence gathered during the scoping stage, the following activities are suggested for the subsequent stages of the LTA (Figure A2.1):

- Strengthening the evidence base on I4.0 readiness – conduct focus group discussions, an industrial survey and a review of the international evidence;
- Planning for implementation – selection and design of mechanisms for the Industry 4.0 roll-out; and
- Implementation roadmaps and partnerships – mechanisms for engaging with partners (chambers of commerce, trade unions, universities, etc.) to promote knowledge and capacity and to co-develop roadmaps and action plans.

Figure A2.1 Roll-out of Industry 4.0 in Cambodia



Based on the evidence gaps identified in this scoping report, and on the suggestions of local stakeholders on the most efficient ways to address these, three activities are proposed for building an evidence base in the next stage of the LTA: focus group discussions with representatives of selected industries, technology suppliers and technology integrators; an Industry 4.0 survey conducted on a sample of manufacturing firms in collaboration with a local partner; and an international review of digital initiatives and applications. Table A2.1 describes the evidence gaps to be addressed through these activities and the advantages of this approach.

Table A2.1 Activities for building an evidence base

Gaps	Evidence-building activity	Advantage
• Sector-level perspectives on the process of technology transfer in Cambodia and key barriers. • Sector-specific trends likely to affect Cambodia's firms.	Focus group discussions with representatives of selected industries, technology suppliers and technology integrators.	• Gain qualitative insights into how technology transfer occurs in Cambodia and the relevant trends. • Validate categories to be used in firm survey.
• Firms' level of awareness of Industry 4.0 technologies. • Firm-level perspectives of barriers to technology transfer and adoption. • Key support mechanisms used by firms. • Application opportunity areas identified by firms.	Industry 4.0 survey conducted on a sample of manufacturing firms in collaboration with a local partner.	• Capture representative data on the most important barriers and support mechanisms used by firms. • Gain representative sector-specific insights on technology awareness and support mechanisms. • Granularity of insights. • Triangulate results from focus group discussions.
• International perspectives on sector-specific application areas relevant to Cambodia. • Effective practices identified by roll-out initiatives in other countries.	International review of Industry 4.0 initiatives and strategies.	• Build on lessons learned from international experiences.

The survey suggested would be aimed at eliciting firm-level information in aspects including: awareness, readiness, barriers and policy options (Box A2.1).

Key themes for the Industry 4.0 survey

Box A2.1 Survey themes

Awareness

- Knowledge of Industry 4.0 technologies;
- Perceptions of the benefits of technologies;
- Knowledge of existing sources of support.

Readiness

- Type of digital technologies use across key business functions;
- Level of technology sophistication on an Industry 4.0 "scale";
- Sources of technology and related technical support.

Opportunities

- Main functional/business areas that could be improved through industry 4.0;
- Popular applications and solutions;
- Successful experiences using Industry 4.0 applications and solutions.

Barriers

- Main problems facing companies in Cambodia;
- Difficulties adopting technologies;
- Advisory services required by firms to build organisational and technological capabilities.

Policy options

- Key areas of support useful to firms;
- Actors and services used by firms for technology transfer;
- Knowledge of existing government initiatives.

A2.2 UNDP's role as an "integrator" of national efforts around Industry 4.0

The UNDP country programme positions UNDP as a strategic partner to government, with the objective of supporting the transition to low-income status through sustainable growth, eliminating poverty and leaving no one behind. UNDP can act as an "integrator",[86] which brings together efforts to help Cambodia achieve the Sustainable Development Goals. A number of areas have been identified in which UNDP could help with coordinating national efforts around Industry 4.0:

- Convening dialogue and promoting common definitions. A number of activities around Industry 4.0 and digital technologies are being planned or taking place in Cambodia, including those by government and development partners. However, because of differences in definitions and approaches, it is not always clear how these activities may be related to one another. The UNDP-convened dialogue could help to ensure mutual visibility of efforts in order to identify opportunities for collaboration and to avoid duplication of efforts. For this to be effective, there is a need to promote the consistent use of sound technical definitions of "Industry 4.0" and other terms such as "Digital Economy" while drawing upon engineering and ICT expertise.
- Building the evidence base on new technologies to inform the national policy agenda. UNDP's evidence-building activities around Industry 4.0 can help to communicate the role of technological innovation in achieving national development goals. Sober analyses of the impact of new technologies on Cambodia's economy are necessary to address unfounded (either overly pessimistic or optimistic) assessments and enable public understanding. A more precise articulation of the opportunities and challenges driven by new technologies – and how they might be addressed in Cambodia – can help to communicate to local stakeholders the benefits of engagement and collaboration while informing the national policy agenda.
- Supporting the articulation of a "vision of the future". The RGC's Rectangular Strategy prioritises transformation towards a greener, skills-based economy linked to innovation and the Fourth Industrial Revolution. Forward-looking studies supported by UNDP can help to inform policy planning by analysing the main trends and drivers shaping specific sectors of Cambodia's economy, accounting for international developments. This can, in turn, help to identify feasible growth targets and underpin a more explicit and action-oriented theory of change.

86 General Assembly resolution 72/279, "Repositioning of the United Nations development system".

- Development of roadmaps and partnerships. Roadmaps facilitated by UNDP could bring together the different stakeholders, activities and resources required to achieve development objectives in the short, medium and long terms. Roadmaps help to turn analytical outputs into actionable plans by "translating" large amounts of evidence into a simplified visual form that dramatically improves ease of communication. During the development of roadmaps, diverse stakeholders co-develop options, decide on key areas of actions and identify next steps for implementation. Roadmapping workshops are in themselves social exercises that help to create a consensus and promote ownership of programme implementation. Roadmaps facilitate visualisation of the necessary resources required for implementation, as well as the opportunities to bring in private and public investment.
- Identifying effective practices from international experience. UNDP's global presence and vast international experience could be leveraged to inform policy thinking and implementation efforts in Cambodia. While no practices from any one country can simply be implemented in another country, regardless of context, opportunities exist to identify principles that underpin effective implementation, as well as lessons learned from less successful attempts. Information about international practice can provide useful insights for policy-makers in Cambodia by highlighting the variety of missions, institutional forms, funding levels and evaluation approaches that it might be relevant to consider when designing interventions.

Annex 3. List of interviewees

Name	Position	Institution
Ms Tan Sodany	Director	ICT Policy Department, Ministry of Posts and Telecommunications
Mr Mao Neang	Deputy Director General¬	General Department of Information and Communication Technology, Ministry of Posts and Telecommunications
Mr Be Chantra	Public Relations Director	National Institute of Posts, Telecoms & ICT (NIPTIC)
H.E. Mey Kalyan	Senior Advisor	Supreme National Economic Council
Ms Pauline Tamesis	Resident Coordinator	United Nations
Mr Sok Narin	Country Representative	UNIDO
Mr Tun Sophorn	National Coordinator	ILO
Ms Sunniya Durrani-Jamal	Country Director	Asian Development Bank
Mr Mar Sophea	Senior Social Sector Officer	Asian Development Bank
Dr Claire H. Hollweg	Senior Country Economist	The World Bank

Annex 4. List of attendees at the focus group discussion with public sector stakeholders

Name	Institution
H.E. Mey Kalyan	Cambodia STI Cluster (Working Group on Industry 4.0)
Mr Srang Sarot	ITC
Dr Hul Seingheng	Research and Innovation Center, ITC
Mr Sar Sambo	ITC
Ms Vong Rylida	Techno Startup Center
Mr Teav Rongsa	General Secretariat of the National Science and Technology Council
H.E. Dr Hor Peng	National University of Management
Dr Phim Runsinarith	National University of Management
Mr To Rith	Ministry of Commerce
Mr Khorn	Ministry of Economy and Finance
Mr Ty Limkosal	Ministry of Economy and Finance
Dr Poch Kongchheng	RCO
Dr Chmit Wornamani	RAC
Dr Chan Oeurn Chey	RUPP
Ms Tan Sodany	Ministry of Posts and Telecommunications
Mr Ouk Samsovathya	National Training Board
Mr Him Phanith	NPCC – MIH
Ms Yos Phanny	ITC
Mr Lor Bunna	CARDI / MAFF
Mr Ly Luch	MIH
Sok Chanreaksmey	NBC
Ms En Sotheavy	NBC
Mr Sot Kimson	MEF
Mr Pong Pitin	MOEYA
Mr At Socheat	Ministry of Mining and Energy
Mr Tep Neavea	ACC
Ms So Sreymom	MAFF
Mr Nick Beresford	UNDP
Mr Richard Marshall	UNDP
Mr Hang Sovannarith	UNDP
Mr Nuon Viraek	UNDP

Annex 5: List of attendees at the focus group discussion with private sector stakeholders

Name	Institution
Mr Ros Khemara	Wing (Cambodia) Limited Specialized Bank
Ms Chan Sorya	The British Chamber of Commerce of Cambodia
Mr Sar Sambo	ITC
Mr Charles J. Esterhoy III	Worldbridge Homes Co., Ltd.
Mr Jackson Chang	COrAA
Mr Hay Phirum	BOSCH
Mr Tassilo Brinzer	German Business Group in Cambodia
Mr Paul Kealey	UNDP
Ms Chloee Konsam	UNDP
Mr Richard Marshall	UNDP
Mr Hang Sovannarith	UNDP
Mr Soy Ratha	UNDP

ABOUT POLICY LINKS

Policy Links is a global not-for-profit innovation policy consultancy unit that works with governments to develop effective industrial innovation policies. We offer new evidence, insights and tools based on the latest academic thinking and international best practice in the areas of technology, manufacturing and innovation policy, with a track record delivering high-impact projects in both developing and developed countries around the world.

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