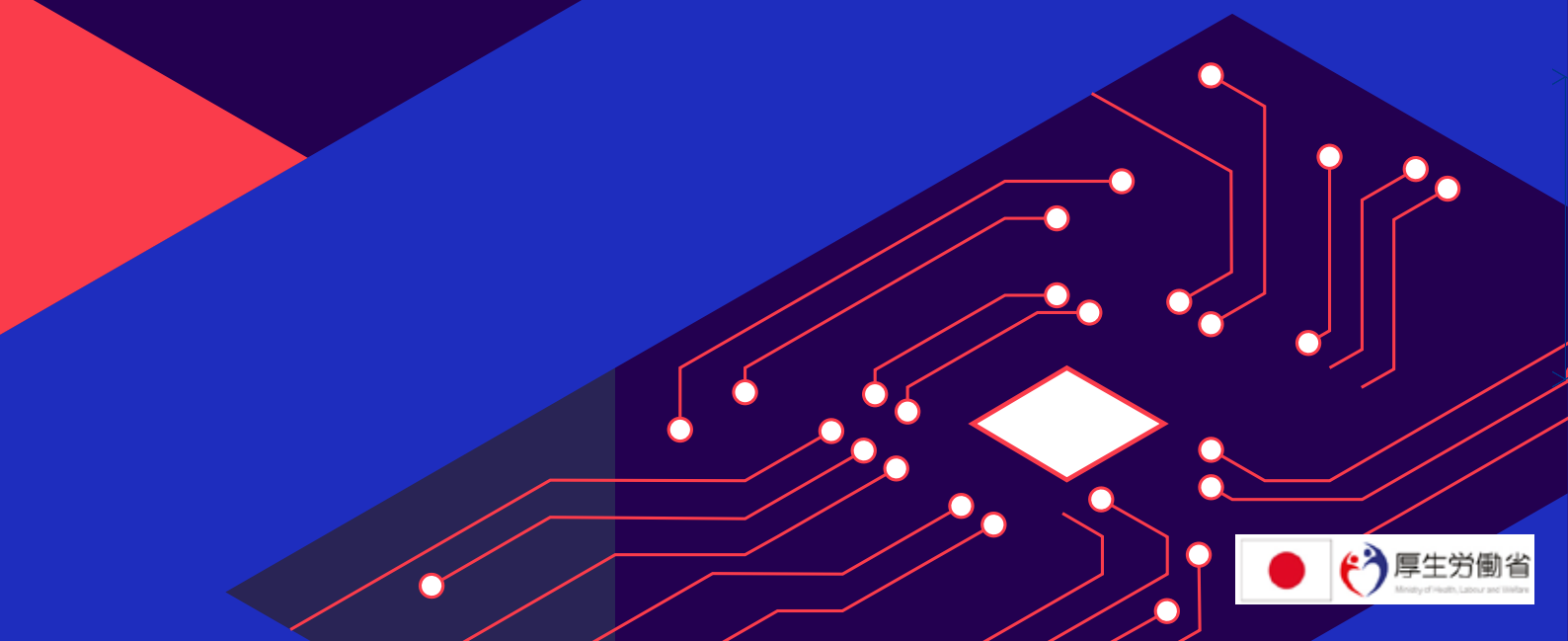
International Labour Organization

Skills shortages and labour migration in the field of information and communication technology in Canada, China, Germany, India, Indonesia, Singapore and Thailand

"The Future of Work in ICT" project

Synthesis report



厚生労働省

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Preface

The International Labour Organization (ILO) is the United Nations specialized agency dedicated to advancing opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. The ILO Sectoral Policies Department promotes decent work by supporting the Organization's tripartite constituents, namely governments, employers and workers, in creating opportunities and addressing challenges in 22 different economic and social sectors at the global, regional and national levels.

Digitalization is a key driver of change. As information and communication technology (ICT) continues to advance and digital technologies are further integrated into sectors across our economies, the skills that are needed the most also continue to change and are increasingly in demand. To better understand the implications for the world of work, the ILO's 'Future of Work in Information and Communication Technology (ICT)' project has for the past two-and-a-half years conducted in-depth research on anticipated needs for skilled ICT workers and formulating strategies to address labour shortages, including the scaling up of investments in ICT education and training, and better governed international labour migration.

This report, the last of a series of three reports, summarizes the project's findings, which were formulated on the basis of research conducted in Canada, China, Germany, India, Indonesia, Singapore and Thailand. The findings presented in the three reports contribute to the ILO's knowledge base regarding the future of work, skills development and effective lifelong learning for all, with a view to supporting the efforts of the ILO's tripartite constituents to advance decent work in the digital economy.

This project responds to the call in the ILO Centenary Declaration for the Future of Work (2019) for "promoting the acquisition of skills, competencies and qualifications for all workers throughout their working lives". It furthermore makes a small but significant contribution to the achievement of several Sustainable Development Goals, particularly Goal 4 on "ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all", Goal 5 on "achieving gender equality and empowering all women and girls", and Goal 8 on "promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all".

Finally, we would like to express our gratitude to the Japanese Ministry of Health, Labour and Welfare for the generous and strategic financial support it has provided for this research project.

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Director
Sectoral Policies Department

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The analysis presented in this report is based on the work of Dr. Nicola Düll (Economix Research & Consulting), who conducted much of the research and wrote the first two reports in the series.

This report was prepared by Shreya Goel, under the supervision of Hitomi Takeuchi-Nakagome, Project Manager, Casper N. Edmonds, Head of the Extractives, Energy and Manufacturing Unit, and Akira Isawa, Deputy Director and Alette van Leur, Director of the Sectoral Policies Department. Elizabeth Fagan, an external consultant, proofread and edited the report.

A sincere thank you is also due to Tomoko Nishimoto, former Regional Director, Rakawin Leechanavanichpan, Programme Officer, Jordi Prat Tuca, Regional Technical and Programme Coordinator, and Jittima Srisuknam, Programme Officer, at the ILO Regional Office for Asia and the Pacific, Graeme Buckley, Director of the ILO Decent Work Technical Support Team for East and South-East Asia and the Pacific and the ILO Country Office for Thailand, Cambodia and the Lao People's Democratic Republic, Claire Courteille-Mulder, Director, and Xiaochu Dai, Deputy Director, at the ILO Country Office for China and Mongolia, Annette Niederfranke, Director of the ILO Country Office for Germany, Dagmar Walter, Director, Sudipta Bhadra, Senior Programme Officer, and Gabriel Bordado, Specialist for Skills and Employability, at the ILO Country Office for India, Michiko Miyamoto, Director, and Tendy Gunawan, Programme Officer, at the ILO Country Office for Indonesia, and, Kevin Cassidy, Director, and Jennifer Mansey, former Public Policy and Communications Officer, at the ILO Office for the United States for their valuable contributions and support in preparing for and carrying out the country-level fact finding missions.

This work also benefitted from valuable input, comments and guidance from a larger group of ILO colleagues, including but not limited to, Uma Rani Amara, Hae Kyeung Chun, Sara Elder, Adam Greene, Christine Hofmann, Rafael Peels, Natalia Popova, Olga Strietska-Ilina and Valentina Stoevska.

Contents

Introduction

Information and communication technology (ICT) is a key economic sector and generator of jobs and may be considered the backbone of the digital economy. However, many countries are facing a shortage of highly-skilled ICT workers, which may affect economic growth. Yet, with the right policies in place, targeted investment in education and training, and improved governance of labour migration, the digital economy is poised to make a significant contribution to advancing decent work and inclusive economic growth at the global, regional and national levels.

The ILO's 'Future of Work in ICT' project has conducted in-depth research on anticipated needs for skilled ICT workers and approaches to address shortages by scaling up investments in ICT education and training as well as better governed international labour migration.

This report is the final report in a series of three reports. It summarizes the findings of the first two reports, which focus on skills shortages, skills development and the migration of highly-skilled ICT workers in Canada, China, Germany, India, Indonesia, Singapore and Thailand. Those reports were prepared on the basis of economic and labour statistics, extensive literature reviews and research mission interviews conducted with representatives from governments, training institutions, universities, research organizations, employers' and workers' organizations, recruitment agencies and private companies in the ICT sector in all seven countries. The present synthesis report draws further on the analysis conducted in the context of the first two reports (ILO, 2019; ILO, 2020a).

This report provides an overview of: (a) trends in the ICT sector, ICT labour markets and the migration of ICT workers; (b) the potential demand for skilled workers and current and anticipated skills mismatches in the digital economy; and (c) strategies for improving ICT education and training. Due to the lack of publicly available data and differences in the definitions used by national statistical offices, it was challenging to compare trends in the ICT sector and employment in the seven countries.

This report furthermore summarizes the key research findings and outlines possible policy responses that could be adopted with a view to scaling up current initiatives to advance decent work opportunities in the digital economy.

1 The digital economy at a glance

Economies and societies around the globe are undergoing a profound transformation due to rapid technological developments and an exponential increase in the use of ICT.

It is difficult to imagine a world without digital technologies. The coronavirus disease (COVID-19) pandemic has further demonstrated the importance of digital readiness. Investing in the necessary infrastructure and taking an inclusive and human-centred approach to technology will be crucial to "building back better" in the post-pandemic world.

The adoption of transformative digital technologies and rapid technological innovation have generated enormous wealth in record time and is key to accelerating progress towards the Sustainable Development Goals. However, digitalization is inevitably leading to major shifts in labour markets everywhere, which have to be managed carefully. The fast-growing digital economy will require a range of new and different skills that do not exist today, both within the ICT sector[1] and in other sectors of the digital economy.[2]

1.1. Trends in the ICT sector

The ICT sector has grown very rapidly in the past few years in the countries examined in the study. The most dramatic growth can be seen in the Indian ICT sector, which increased from 1.2 per cent of gross domestic product (GDP) in 1998 to more than 7.9 per cent in 2018 (India, Ministry of Electronics and Information Technology (MEITY), n.d.). In Canada, growth in the ICT sector outpaced overall growth of the economy between 2014 and 2018 (Canada, Information and Communications Technology Council (ICTC), 2019).

Table 1: ICT sector as a percentage of national GDP

Country (year)	Contribution of ICT sector* to total GDP (%)
Canada (2018)	4.5
China (2015)	4.8
Germany (2017)	4.2
India (2018)	7.9**
Indonesia (2016)	7.2
Singapore (2018)	4.1

*The countries examined have adopted various definitions of the ICT sector

** Figure refers only to the IT sector

Note: data for Thailand on the size of the ICT sector was unavailable

Sources: ICTC, 2019 (Canada); OECD, 2019 (China); Federal Ministry for Economic Affairs and Energy, 2018 (Germany); MEITY, n.d. (India); Agahari, W., 2017 (Indonesia); Ministry of Trade and Industry, 2018 (Singapore).

1 According to the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4, ICT sector job classifications include classifications 2610, 2620, 2630, 2640 and 2680 (ICT manufacturing industries), 4651 and 4652 (ICT trade industries), 5820 (ICT service industries), 6110, 6120, 6130 and 6190 (telecommunications), 6201, 6202 and 6209 (computer programming, consultancy and related activities), 6311 and 6312 (data processing, hosting and related activities; web portals), and 9511 and 9512 (repair of computers and communication equipment).

2 While there is no agreed definition of the digital economy, it is considered to include the IT/ICT sector and emerging digital business models. Some entities also include the wider applications of digital technologies in existing businesses as part of the digital economy.

In line with global trends, the growth in the ICT sector in most of the countries examined is currently driven by growth in the ICT services subsector (UNCTAD, 2019). However, ICT manufacturing has underpinned ICT sector growth in China and the export of ICT goods, including hardware, has fuelled the growth of the ICT sector in Thailand.

▶ 1.2. ICT specialists[3] in the world of work

Research data from the seven countries examined shows that ICT specialists tend to be younger than the average worker and overwhelmingly male. The proportion of immigrants working in ICT occupations is also higher than the proportion of immigrant workers in the broader economy.

1.2.1. Employment statistics

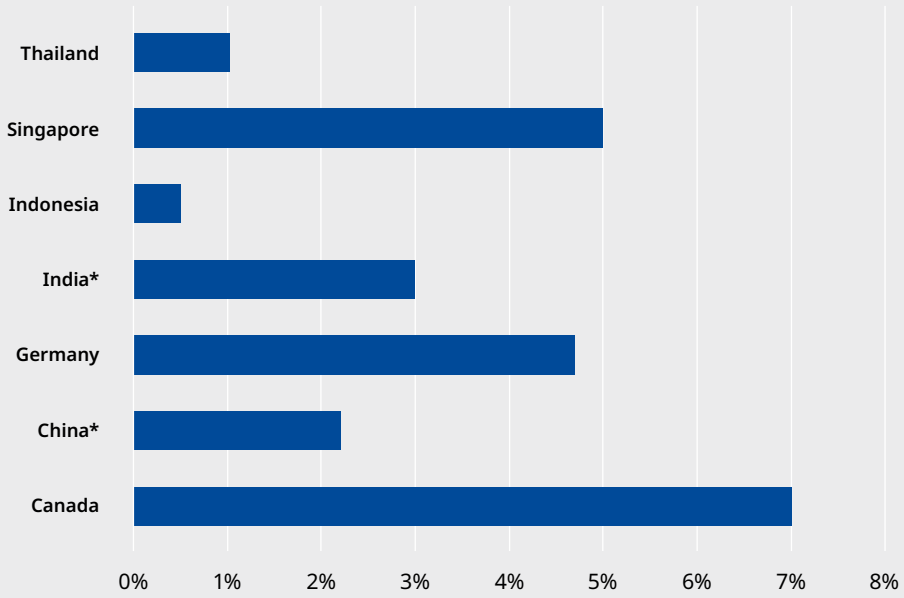
As shown in Figure 1, ICT specialists account for an important percentage of the workforce in several of the countries examined.

Canada had the highest share of ICT specialists, who account for approximately 7 per cent of the country's workforce. If we look at absolute numbers, India had the largest number of ICT specialists: while the exact number was unavailable, the IT industry in that country employed approximately 10 million workers, including ICT specialists.

ICT specialists have become some of the most in-demand workers in many countries. In Canada, ICT sector employment grew at a faster pace than employment in the broader Canadian economy between 2014 and 2018. While ICT specialists comprise only a relatively small percentage of the workforce in Thailand, ICT sector employment in that country increased at an annual rate of 7 per cent between 2012 and 2017.

The research revealed that more than 50 per cent of ICT specialists in Canada, Germany and Singapore were employed in non-ICT sectors, for example in the financial sector. It is anticipated that the share will increase further in the future as digitalization gains pace. In Indonesia, employment growth for ICT specialists was greater in certain economic sectors, including e-commerce, than in the ICT sector itself. While such data are not available for China, India and Thailand, national-level experts have emphasized that there is significant demand for ICT specialists in other sectors of the economy.

▶ **Figure 1. Share of the national workforce employed as ICT specialists in the seven countries**

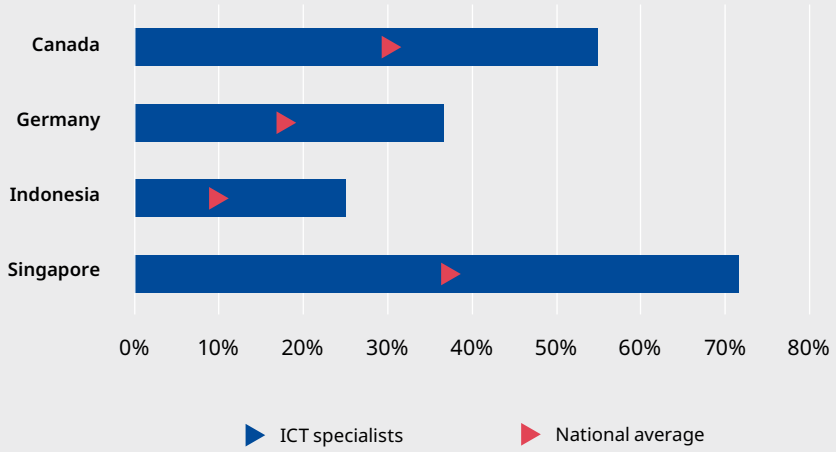


***Data for number of ICT specialists for India and China is unavailable and instead the number of persons working in the ICT industry is used

Sources: ICTC, 2019 (Canada); OECD, 2019 (China); ILO Labour Force Survey, 2017 (Germany); OECD, 2018 (India); Statistics Indonesia (BPS), 2018 (Indonesia); Chua, A., 2018 (Singapore); National Statistical Office Labor Force Survey 2017 (Thailand).

3 This report uses the definition of "ICT specialist" developed by OECD and Eurostat. According to International Standard Classification of Occupations (ISCO) – 08, OECD and Eurostat, ICT specialists are highly-skilled workers, and include ICT services managers, electrotechnology engineers, ICT professionals, and information and communications technicians.

Figure 2. Percentage of ICT specialists with university degrees compared to the national average for non-ICT workers



Note: relevant data is unavailable for China, India and Thailand

Sources: Government of Canada, 2020 (Canada); Background report, 2019 (Germany); National Labour Force Survey (SAKERNAS), Statistics Indonesia (BPS), 2018 and ILO, 2017 (Indonesia); Infocomm Media Development Authority (IMDA), 2019 (Singapore).

1.2.2. Education

In general, ICT specialists are better educated than non-ICT workers. As illustrated in Figure 2, the percentage of ICT specialists with a university degree was higher than the percentage of non-ICT workers in four of the seven countries.

However, the figures above should be interpreted with caution when comparing the qualification levels of ICT specialists in different countries. For example, a large share of ICT specialists in Germany acquired their qualifications at vocational training, where it is historically well-developed, whereas in Indonesia, universities are perceived as providing a better education than vocational training institutes. A significant percentage of ICT specialists in Canada obtain qualifications from colleges instead of universities, since colleges generally provide more practical, hands-on career training.

Although relevant data for China, India and Thailand were unavailable, research interviews and surveys from specific segments of the ICT sector indicated that the level of educational attainment among ICT specialists in those countries was high. For example, a survey conducted among 600 companies in the Chinese semiconductor industry found that most individuals employed in that industry had obtained at least a bachelor's degree.

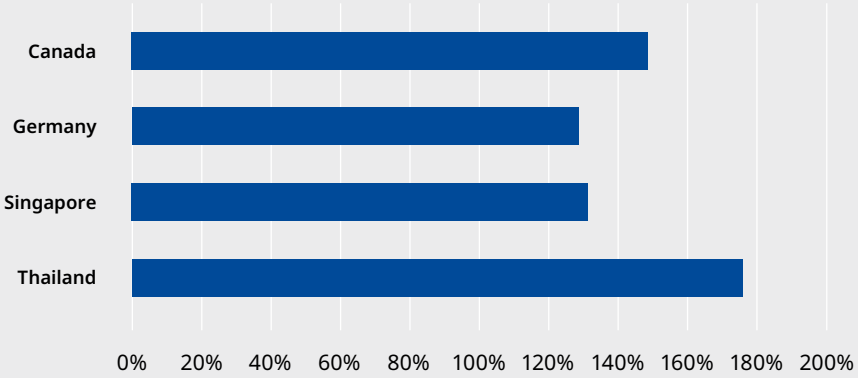
Research has also revealed that certifications offered by private companies and other forms of non-formal education are gaining in importance. These trends can be explained by the shortage of ICT specialists in the light of rapid technological change.

1.2.3. Wages

Due to fierce competition for ICT specialists, the wages paid to them have been increasing and are expected to continue to rise. The most dramatic increase can be seen in China, where wages in the ICT sector doubled between 2012 and 2016, whereas average wages in China grew by only 50 per cent during the same period. Wages paid to ICT specialists in India have also risen sharply as the Indian IT services sector has moved up the value chain. In Singapore, the wages of ICT specialists have increased at an annual rate of 6.5 per cent in the last two years.

In all seven countries, ICT specialists earn higher wages on average than workers in other occupations. Figure 3 illustrates how much ICT specialists earn relative to the national average in Canada, Germany, Singapore and Thailand.

▶ Figure 3. Income of ICT specialists relative to the overall national average



Note: relevant data is unavailable for China, India and Indonesia; differences in definitions of occupations and scope of wages do not allow for comparative analysis

Sources: Government of Canada, 2020 (Canada); Federal Association for Information Technology, Telecommunications and New Media (Bitkom), 2019 (Germany); Ministry of Manpower, 2018 (Singapore); Thailand Board of Investment (BOI), 2017 (Thailand).

The difference in wages was largest in Thailand, followed by Canada, Singapore and Germany. In Canada and Singapore, even the lowest paid categories of ICT specialists earned more than the national average. For example, those working in ICT manufacturing and communication services in Canada were the lowest paid workers in the Canadian ICT sector but still earned 27 per cent more than the national average.

In most of the countries, those working in ICT manufacturing earned lower wages than those working in ICT services. The highest paying subsectors varied by country. The highest earners in the integrated circuit industry in China worked in ICT design, while the highest earners in the Indonesian ICT sector worked in telecommunications.

Research interviews highlighted that high wages have made the recruitment of ICT specialists particularly difficult for small and medium-sized enterprises.

In addition to competitive wages, both small and large ICT companies in the seven countries have sought to recruit workers by offering other benefits and amenities, such as continuous training, and attractive working environments.

1.2.4. Female employment in the ICT sector

Approximately a third of all ICT specialists are women and the share of women working in ICT is well below economy-wide averages in all of the countries with the exception of India (Figure 4). While research interviews carried out as part of this project indicated that the share of female ICT specialists was below the overall national average in China, relevant data on that issue is not publicly available.

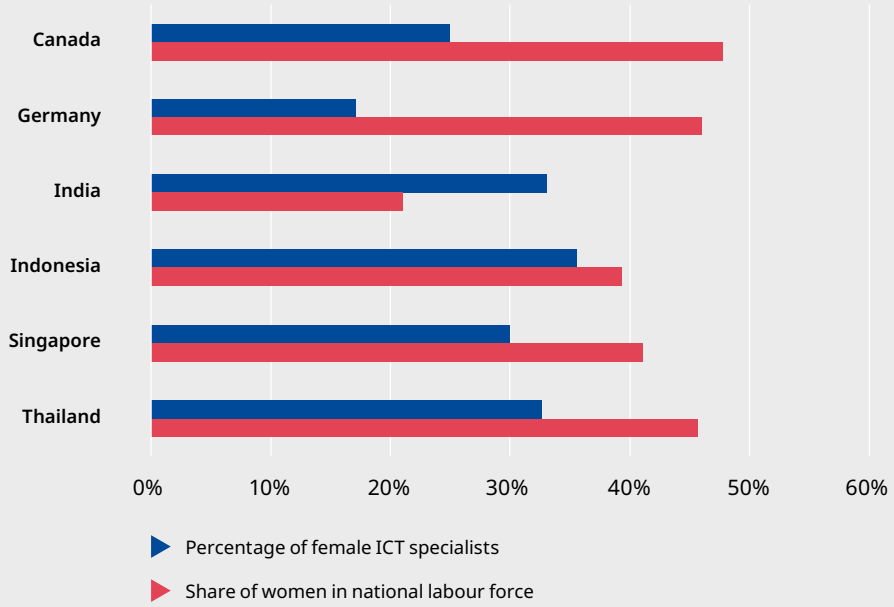
The largest differences between national averages and female participation rates in ICT can be seen in Germany and Canada. In India, the share of female ICT specialists is higher than the share of women in the national labour force. However, the share of women in the labour force is particularly low due to a number of factors including discrimination, gender stereotypes, occupational segregation and a lack of formal job opportunities for women. Further research is required to understand why the share of female ICT specialists in India is higher than the average share of women in the labour market .While the share of women working in ICT has been increasing in all countries, much remains to be done to increase the participation of women in that sector.

There are, moreover, large variations in the share of women by occupational subgroup. In Canada, Germany and Singapore, for example, very few women work in software development and programming. The share of women is much larger in the media, health, business administration, and graphic arts.

The share of women is also much larger at entry level positions compared to managerial positions. Figure 5 below illustrates the share of women at entry, middle management and senior management levels in the Indian ICT sector.

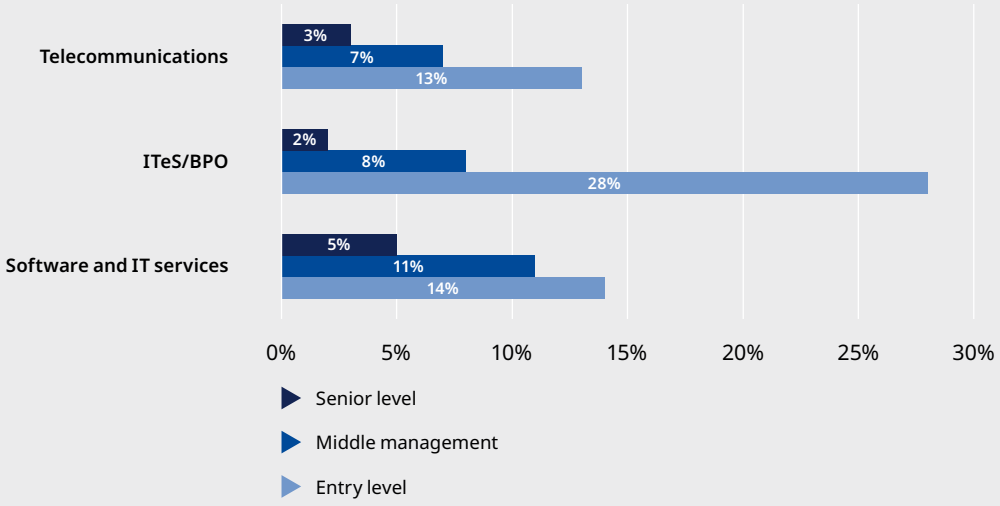
Similar trends have been observed in Germany and Canada. Surveys on the experience of women in the Canadian tech industry have highlighted that women often feel excluded from decision-making processes and that their voices are rarely heard (Brookfield Institute, 2019).

Figure 4. Percentage of ICT specialists who are female compared to the proportion of female workers in the national labour force in selected countries



Sources: ICTC, 2019 (Canada); author calculation on the basis of data provided by the Federal Employment Agency (BA) (Germany); India Skills Report, 2014-2018 (India); BPS, 2018 (Indonesia); IMDA, 2019 (Singapore); National Statistical Office Labour Force Survey, 2017 (Thailand).

Figure 5. The share of women at entry, middle management and senior levels in selected IT subsectors in India (per cent)



Note: ITeS/BPO stands for Information technology-enabled services and business process outsourcing

Sources: Indian National Association of Software and Service Companies (NASSCOM), 2014; Harvard Kennedy School, Evidence for Policy Design Initiative, 2013.

1.2.5. Employment of mid-career and older workers

Less than 10 per cent of ICT specialists in India, Indonesia, Thailand and Singapore are over the age of 50. Company level surveys in several of the countries examined have indicated that companies prefer to hire younger ICT specialists. Some companies perceive older workers as being less technologically proficient and slower to adapt to a new company culture. Other companies noted that while older workers were adaptable, it was more expensive to upskill and reskill them. However, research also suggests that ICT companies can leverage the untapped potential of older workers. In that connection, several programmes have been launched in Singapore with the aim of reskilling mid-career and older workers workers to take up positions in the ICT sector.

1.2.6. Migrant ICT specialists

In general, ICT specialists are a highly mobile workforce. Global migration of ICT workers has been on the rise over the last three decades, fuelled by fierce international competition to attract them. To that end, several countries, including Canada, China and Germany, have implemented favourable visa policies to attract highly-skilled ICT workers (ILO, 2020a).

A large number of Indian ICT specialists work abroad. This may be due, inter alia, to the large supply of ICT specialists in India that are keen to migrate. In addition to highly skilled Indian workers migrating due to job opportunities, there has been an increase in the number of skilled Indians emigrating through the academic stream. Although limited data on the destination countries for Indian ICT specialists is available, databases from individual Indian universities suggest that a large percentage of their graduates find employment abroad. The United States of America, the United Kingdom and certain non-English speaking European countries, including Germany, were important destination countries.

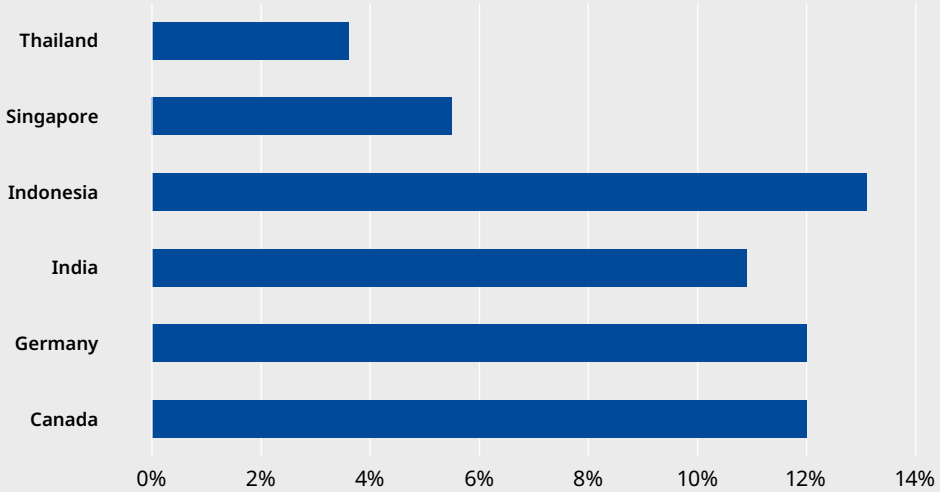
The international migration of ICT specialists to Canada, China, Germany and Singapore has increased rapidly in recent years due to high labour demand and skills shortages in those countries. Immigrants accounted for over 50 per cent of employees in certain ICT subsectors in Canada.

The proportion of foreign-born ICT specialists is higher than the economy-wide average in Canada and Germany, and around average in Singapore. In China, the percentage of skilled and highly-skilled foreign workers, including ICT specialists, remains low.

▶ 1.3. Self-employment and platform work

Self-employment, and temporary or freelance contracts are also present in the ICT field. The lack of

▶ **Figure 6. Percentage of ICT specialists who are self-employed**



Note: figures for India, Indonesia and Thailand only refer to workers in the ICT sector specifically, and excludes ICT specialists working in other sectors of the economy

Sources: Statistics Canada, 2016 Population Census (Canada); Labour Force Survey data, 2016 (Germany); national background report (Singapore); ILO databases (India, Indonesia, Thailand).

statistics on the share of self-employment, temporary work and freelancing among all highly-skilled workers do not allow for assessing if it is more pronounced among ICT specialists. Figure 6 below illustrates the percentage of ICT specialists who are self-employed in six of the seven countries. Data on self-employment among ICT specialists in China is not publicly available.

Online platform work is the most widespread form of self-employment for ICT specialists. Regional level data from Asia and national level data from Germany and Canada show that software developers account for the largest share of ICT specialists that were engaged in online platform work.

There are several benefits and challenges to platform work. The severity of these challenges may differ by country, the size of platforms the workers are engaged in, and the workers' skill level. Further research is required to understand these nuances.

Companies can use platform work to meet specific skills needs for projects and overcome labour shortages in sectors in which it is difficult to recruit sufficient numbers of workers. At the same time, platform work can provide workers with additional income and an opportunity to enter the labour force while also upholding family or other responsibilities. It can also provide flexible employment opportunities for persons with disabilities (ILO, 2020a). Trade unions in Singapore believe that platform work can serve as a bridge to the labour market, in particular for mid-career and older workers, and enables them to gain valuable work experience in the ICT field (Research mission interview with the National Trades Union Congress (NTUC), Singapore).

Despite the benefits listed above, platform work can also pose several challenges for workers. For example, platform workers tend to work long hours, are often poorly paid, and often lack job security as well as access to social security systems. It also poses a risk for skills development as the responsibility for upskilling or reskilling lies solely with the worker (ILO, 2019; ILO, 2020a). While some ICT specialists working as platform workers voluntarily chose that form of employment, other ICT specialists are obliged to accept platform work because they have not been offered a permanent work contract.

▶ 1.4. Working conditions and occupational safety and health

In general, ICT specialists face lower occupational safety and health risks than workers in other occupations. While physical risks are limited, however, many individuals working with digital tools[4] complain that they suffer from musculoskeletal disorders and eye strain. Working with digital tools can also cause mental health issues.

In Germany, a survey of 9,600 employees conducted by the German Trade Union Confederation (DGB), showed that employees who work extensively with digital work tools feel stressed and under time pressure more often than workers who do not work with digital work tools (Institut DGB, 2017).

Data from Canada, China and Germany indicate that ICT specialists tend to work longer hours than workers in other fields. In Germany, for example, ICT specialists reported that they worked longer unpaid overtime hours than those working in manufacturing. Some ICT specialists working for private companies in China work according to the "996" culture where they work from 9 am to 9 pm for 6 days per week (Research mission interview with China Enterprise Confederation/ China Enterprise Directors Association (CEC/CEDA)). The long hours worked by ICT specialists and stress related to tight ICT project deadlines often cause physiological symptoms, including headaches, nervousness and irritability.

It is particularly difficult to ensure that ICT specialists hired to perform online platform work are not obliged work unduly long hours (Lehdonvirta, 2018). Furthermore, the lack of job security associated with online platform work can cause additional distress, especially for those who do not voluntarily choose to take up that form of employment.

Discrimination, violence and harassment against women are also of concern in ICT occupations. Research from India has indicated that, although certain companies have implemented gender-focused strategies, awareness of gender discrimination, sexual harassment and the particular working conditions of women might still be lacking. For example

4 Encompasses all the technologies, such as applications and websites, that people use to perform work

a non-representative survey conducted by Ernst and Young Forensic & Integrity Services among 120 employers in India, of which 17 per cent were in the IT/ITeS sector, found that 27 per cent of the large companies and 50 per cent of the small and medium-sized companies were failing to comply with federal regulations to prevent sexual harassment against women in the workplace (Ernst and Young, 2015).

▶ 1.5. Key actors in the digital economy – governments, employers' and workers' organizations

In all seven countries, ministries responsible for labour, education, technology and immigration are supporting the development of the digital economy. A number of countries have also established bodies that focus specifically on skills development, including for example, the Ministry of Skill Development and Entrepreneurship in India and SkillsFuture Singapore.

Various ministries and government agencies in the seven countries, including ministries of labour, education and industry, promote skills development and help formulate international labour migration policies and strategies to ensure decent work for workers in ICT occupations. However, coordination among those stakeholders is often weak at the regional, national and local levels. It should be emphasized that better coordination among those stakeholders could enhance the formulation and implementation of policies, thereby strengthening their coherence and effectiveness and further advance decent work in the digital economy.

Constructive social dialogue among tripartite constituents, namely governments, employers' and workers' organizations, can play a crucial role in addressing challenges in the ICT field. According to the ILO Declaration on Fundamental Principles and Rights at Work and its Follow-Up, all ILO Member States have the obligation to respect, promote and realize the principles concerning the fundamental rights, namely the elimination of all forms of forced or compulsory labour, the effective abolition of child labour, the elimination of discrimination in respect of employment and occupation and the right to freedom of association and the effective recognition of the right to collective bargaining. The ILO Conventions covering right to freedom of association and the effective recognition of the right to collective bargaining are the Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87) and the Right to Organise and Collective Bargaining Convention, 1949 (No. 98). Compliance with those conventions is a prerequisite for the attainment of the four strategic objectives prescribed in the ILO Declaration on Social Justice for a Fair Globalization, adopted in 2008. In the ICT sector, the tripartite constituents have sought to address issues such as skills development, networking, mobility, gender equality and non-discrimination, ageing, working time arrangements, platform work, and mental health.

While employers' associations in the ICT sector are active in all seven countries, there are very few unions representing ICT sector workers. This may be due, inter alia, to ICT workers' relatively good working conditions, including their relatively high wages, and new forms of organizing work among ICT workers. Trade unions in the ICT sector have only recently been established in India and Indonesia in the wake of labour disputes in that sector. Representative and strong employers' and workers' organizations can play a crucial role in advancing decent work for both women and men in the ICT sector.

2 Anticipated skills needs in the digital economy

Rapid technological progress is transforming the nature of jobs and the skills required to perform them. Research conducted as part of this project revealed that all seven countries face a shortage of ICT specialists with specific skills. Those skills mismatches[1] can create inefficiencies and indicate that workers themselves or broader society have invested in the development of skills that are not required in the labour market, while companies are unable to find workers with the particular skills they require. This can increase the direct and indirect costs that must be borne by governments, companies and individuals. Tackling those mismatches has therefore become a major concern for governments, employers and workers in all seven countries.

2.1. Shortages and future demand of ICT specialists

As mentioned previously, all seven countries are facing significant shortages of ICT specialists. A survey conducted in Germany by the industry association Bitkom estimated that Germany faced a shortage of 124,000 IT specialists in September 2019, while the National Statistical Office of Thailand conducted a survey in 2017 that concluded that there was a shortage of 450,000 ICT specialists in that country. In India, the industry association NASSCOM concluded that the country's IT and business-process management industry required an additional 140,000 ICT specialists in 2018 (Akella, 2019).

In addition to current shortages, skills forecasting data from Canada, Germany and Singapore indicate that demand for ICT specialists is expected to increase significantly in the future. According to data provided by the Canadian Occupational Projection System (COPS), managed by Economic and Social Development Canada (ESDC), the number of job openings for core ICT occupations is predicted to increase by 40 per cent between 2018 and 2028. A labour market forecast commissioned by the German Federal Ministry of Labour and Social Affairs (BMAS) estimated that demand for ICT specialists would increase by 26.3 per cent by 2035. Singapore's Annual Survey on Infocomm Media Manpower of 2019, using a shorter time horizon than Germany and Canada, estimated that the demand for ICT occupations would increase by 28 per cent between 2019 and 2021. The increasing demand for ICT specialists means that it is vital to take steps to address current shortages and to invest in the development of highly-skilled talent to meet future labour market needs.

In some of the countries, the seriousness of the shortage varies depending on the qualification level of the ICT workers concerned. According to the Indonesian Ministry of Communication and Informatics (KOMINFO), there is a shortage of ICT specialists with a masters' degree and above. This is also the case for China, with the integrated circuit industry in particular experiencing an acute shortage of high-end talent (Boston Consulting Group, 2017; Chinese Academy of Personnel Science, n.d.). In Germany, shortages can be

1 Skills mismatch is an encompassing term that refers to different types of skills gaps and imbalances, including over-education, under-education, over-qualification, under-qualification, over-skilling, skills shortages, skills surpluses and skills obsolescence. Skills mismatches can be both qualitative and quantitative and refer to both situations in which an individual does not meet the requirements of a specific job and in which there is a shortage or surplus of individuals with a specific skill. Skills mismatches may be identified at the level of individuals or employers, or within specific economic sectors or the broader economy. Several types of skills mismatch can coincide.

found among ICT specialists at all qualification levels (Federal Employment Agency (BA), 2019).

2.1.1. By sector and occupation

Vacancies for certain ICT occupations are more difficult to fill than others. Table 2 below lists the ICT positions that are particularly difficult to fill in Canada, Germany and Indonesia. Relevant data for China, India, Singapore and Thailand were unavailable.

2.2.1. Technical skills

Skills specific to cloud computing and artificial intelligence (AI) are among the most in-demand skills in five of the seven countries (Canada, China, Germany, India and Singapore) (ILO, 2019; ILO, 2020a). Companies also find it particularly challenging to recruit workers with skill sets in areas such as software development, business intelligence and advanced analytics.

Demand for technical skills also varies by country. In India, the Federation of Indian Chambers of Commerce and Industry estimates that between 60 and 70 per cent of the IT workforce will need reskilling in areas such as biotechnology[2], nanotechnology, self-monitoring analysis and reporting technology (SMART) and advanced analysis.

▶ **Table 2: ICT job positions that are particularly difficult to fill, selected countries**

Country	In-demand job positions that are particularly difficult to fill
Canada	software developer, data scientist, data analyst, user experience (UX)/user interface (UI) designer, full stack developer, cybersecurity analysist, developing operations engineer, machine learning engineer, database administrator, IT support specialist
Germany	electrical technician, software developer, IT-application consultant
Indonesia	web developer/web programmer, graphic designer, front-end developer and programmer, Android developer, Java developer and programmer

Note: the level of difficulty varies by country; occupations with the same name may not be fully comparable across countries

Sources: ICTC, 2019; German Federal Employment Agency (BA), 2019; ILO, 2018

In China, the sectors most affected by a shortage of talent were e-commerce, computer software, and IT services (Research mission interview with Zhaopin Ltd., China). At the sectoral level, the animation sector of Indonesia faces a significant shortage of between 15,000 and 20,000 ICT specialists (Asosiasi Industri Animasi Indonesia, n.d.).

These examples illustrate the importance of understanding the shortage of talent at a more granular sectoral and occupational level. To address emerging talent shortfalls in the ICT sector, it is also critical to identify the specific skills that are in demand.

▶ 2.2. Skills needs and gaps

Emerging technologies and the development of new occupations associated with them is significantly changing workers' skills requirements, posing huge challenges for the ICT sector, higher education institutions, and the broader workforce.

2.2.2. Soft skills[3]

Research and interviews in all seven countries revealed that technical skills alone are not sufficient in the workplace. Rapid technological change requires that workers adapt quickly, which calls for effective lifelong learning policies that equip workers with, inter alia, relevant soft skills that help them adapt to such rapid developments (see table 3). Soft skills are therefore becoming increasingly important.

Employers in the seven countries noted that it was difficult to recruit ICT specialists with the required soft skills. In Canada, for example, 23 per cent of employers who participated in a digital economy employers survey agreed that "finding employees with both technical and business-interpersonal skills" was the main skills-related challenge for their company

2 See section 2.2.3 on interdisciplinary skills

3 Also known as "core skills". For further details, see: Enhancing youth employability: What? Why? and How? Guide to core work skills (ILO, 2013), and Regional Model Competency Standards: Core competencies (ILO, 2015). Further information on core skills will also be made available in the forthcoming ILO skills framework.

▶ **Table 3: Soft skills required in a technologically intensive environment**

General requirements in ICT occupations	Required soft skills
Developing and using technologies	Critical thinking, analytical thinking, creative thinking, problem-solving skills
Coping with technological change	Ability to learn, flexibility
Understanding the organization of work and maintaining client relations	Teamwork, leadership, communication, service orientation, business and management skills

Source: author analysis

(Cameron and Faisal, 2016). Furthermore, 41 per cent of respondents who took part in a survey of the ICT service sector in Singapore that was conducted by the industry association SGTech reported that soft skills were the main skills gaps in the industry (SGTech, 2019). Another survey conducted among 856 ICT companies in Germany revealed that almost a third of companies found job applicants lacking in soft skills (Bitkom 2019).

A lack of soft skills is particularly evident among recent graduates. Concerns about the job readiness of recent graduates because of their lack of soft skills were noted by industry associations in Singapore and Canada (SGTech, n.d.; ICTC, 2016). It is also important to note that on-the-job training for recent graduates can be expensive, and the lack of soft skills among graduates therefore has a disproportionate impact on small and medium-sized enterprises.

2.2.3. Interdisciplinary skills

The increasing role of technology across all sectors of the economy is also driving demand for interdisciplinary skills. There is, for example, increasing demand for skills in areas such as AI, cloud computing, big data and cybersecurity, as well as in business intelligence. ICT specialists with knowledge of specific programming languages are also greatly in demand. The ability to work in interdisciplinary fields and some knowledge of other study fields is becoming increasingly important as technological complexity increases and innovative digital technologies are adopted across a wide range of sectors and fields, including agriculture, medicine and health, education and banking. It is therefore crucial that higher education institutions adopt interdisciplinary approaches, for example by setting up combined study courses and by promoting interfaculty teaching and research exchanges.

The importance of interdisciplinary skills was also highlighted by the results of a recent survey of 220 companies conducted by the Deutsche Akademie der Technikwissenschaften (acatech) in which companies were asked about the skills necessary for Industry 4.0. The survey found that interdisciplinary thinking and acting was considered to be one of the most critical skills requirements for companies (acatech, 2016).

3

Strategies to equip people with in-demand skills

Effective collaboration and coordination among all relevant stakeholders are crucial if stakeholders are to formulate robust strategies for skills development. The ILO Human Resources Development Recommendation, 2004 (No. 195) emphasizes the role of social dialogue in formulating, applying and reviewing national human resources development, education, training and lifelong learning policies, and provides that Members should, inter alia, "recognize that education and training are a right for all and, in cooperation with the social partners, work towards ensuring access for all to lifelong learning".

3.1. Lifelong learning in the ICT field

As outlined in Box 1, a comprehensive human-centred approach to lifelong learning will be crucial if workers are to adapt to rapid change as the demand for digital skills evolves.

In the area of ICT, lifelong learning has the potential to facilitate and accelerate digital transformation, support national innovative capacity, facilitate occupational mobility, respond to challenges arising from demographic change, and provide equal access to skills development.

Among the seven countries examined, Canada, China, Germany and Singapore have implemented policies on lifelong learning. For example, the "China Education Modernization 2035" plan promotes the establishment an institutional environment for lifelong learning, involving actors in both education and industry.

It should be noted, however, that in recent years lifelong learning has increasingly been used as a proxy term for adult education and training (ILO, 2019). In light of rapid technological change, it is important that comprehensive lifelong learning policies are adopted to equip workers with strong foundational skills, starting at the early childhood education stage, to prepare them for a lifetime of learning.

Box 1: What is lifelong learning?

While the definition of lifelong learning can differ nationally and internationally, it can generally be defined as "all learning activities undertaken throughout life for the development of competencies and qualifications" (Human Resources Development Recommendation, 2004 (No. 195)).

To mark its 100th anniversary, the ILO adopted the Centenary Declaration for the Future of Work at the 108th session of the International Labour Conference, held in June 2019. This forward-looking Declaration calls upon all the ILO member States to give significant importance to "effective lifelong learning and quality education for all".

3.2. Post-secondary education (universities and vocational education and training institutes)

Strengthening the capacity of post-secondary education is vital if countries are to tackle skills shortages in the field of ICT. In all seven countries, graduates in ICT fields often lack specific technical and soft skills that they will need to succeed in the workplace. As was outlined in Chapter 2, while the number of ICT graduates was generally sufficient in India, Indonesia and Thailand, there was a significant shortage of ICT graduates in Canada, China, Germany and Singapore. Furthermore, although increasing numbers of students are pursuing studies in ICT fields in the latter four countries, the increasing number of ICT graduates is still failing to keep pace with labour market needs.

The skills gaps and shortages associated with post-secondary education could stem from:

- Institutions' limited capacity to increase the number of graduates;
- Curricula that fail to reflect the rapid technological development and their adoption in industries;
- Curricula and teaching methods that place insufficient emphasis on the development of soft skills;
- Insufficient numbers of teaching staff with the capacity to teach relevant skills, including technical skills, soft skills and industry- and domain specific skills;
- Lack of interdisciplinary approaches;
- Insufficient work-based learning;
- Insufficient collaboration among educational institutions and social partners; and
- Mismatches between long- and short-term outlooks in education, i.e. the failure to strike an appropriate balance between skills required for employment and skills that will enhance graduates' adaptability in the future.

Continuous training for teaching staff can help teachers update their teaching methods and skills so as to prepare students for future labour market needs. An example of continuous training for teachers can be seen at the Beuth University of Applied Science in Germany, where online courses for teachers and teaching staff in computer science are now designed. Another example is Beijing Information Technology College, which runs a teaching centre dedicated to providing continuous training for teachers at vocational schools across the country.

Social partners have a particularly important role to play in shaping post-secondary education. However, processes for involving workers and employers are not always institutionalized, and cooperation depends on several factors such as a culture of dialogue, a perceived mutual interest, strong and independent employers' and workers' organizations, and policies and institutions that support their active engagement. While post-secondary educational institutions in most of the countries examined in this study engage in dialogue with employers' and workers' organizations, the extent of that engagement varies considerably among institutions. In Canada, China, Germany and Singapore, for example, companies, industry associations and sector councils are consulted as part of the curriculum development process. Findings from all countries also indicate that, although numerous communication channels have been established, curricula are not being updated at the speed required.

3.2.1. Work-based learning for students and recent graduates

Skills gaps among graduates can make the transition from higher education to the workplace extremely difficult and many graduates require several months of on-the-job training to address those gaps. Workplace learning is now recognized as an important tool that enables individuals to gain key technical skills and, more importantly, soft skills. To support that process, internships and other forms of work-based learning are now being encouraged in all seven countries.

Another form of practical learning has been the establishment of projects that students can work on that are eventually developed and implemented by private or public sector entities. Such project-based learning facilitates the application of foundational and practical knowledge in "real-world projects". For example, the Indian Institute of Information Technology and Management (IIITM) Gwalior, now offers a master's degree programme that includes a project year, in which students work on developing projects such as a research paper, an app, or other software. Evidence has shown that the project work significantly increases students' chances of being hired in the ICT industry

upon graduation (Research mission interview with IIITM Gwalior).[1]

In all seven countries, work-based learning most commonly takes the form of internships. While apprenticeships are also a popular form of work-based learning in India, Indonesia and Thailand, they cater mostly to occupations that required relatively low technical skill levels. In Canada, China, Germany and Singapore, internships have been integrated into university curricula in tertiary education and are often mandatory. Internships are often used by companies as a recruitment tool in those four countries. At Tsinghua University in China, for example, curricula include internships with companies that last approximately three months, which help students acquire practical skills. Many companies view such internship programmes as effective recruitment channels (Research mission interview with Tsinghua University, China).

In Germany, a number of universities are adopting a dual approach to learning that combines university education with on-the-job training. Participating companies, which include Siemens, Deutsche Telekom and Volkswagen, are often extremely keen to hire graduates of such dual approach programmes.

In addition to improving the employability of graduates, work-based learning has also helped education institutions revise and update their curricula, including on the basis of feedback provided by companies that provide work experience to their students (Research mission interviews with IIITM Gwalior, India and SkillsFuture Singapore). Despite progress in that area, however, employers in several of the countries surveyed emphasized that more needed to be done to prepare graduates for the labour market.

3.2.2. Soft skills

Higher education institutions have started to integrate soft skills into their curricula. However, there is still scope for further efforts in that area. For example, the British Columbia Institute of Technology (BCIT) uses project-based learning in order to impart problem-solving skills and teach creativity (Research mission interview with BCIT, Canada).

A different approach has been adopted by the Faculty of Computer Sciences and Mathematics at the Munich University of Applied Sciences (MUAS), which has developed its own testing methodology to assess the cognitive skills of ICT students in the areas of logic and abstract and analytical thinking, at the beginning of first year of study. Students receive their individual results, which they can compare with the expected benchmark. Preparatory courses are then offered to close skills gaps. Teaching staff receive average results for the cohort to help them understand their students' training and upskilling needs and fine tune course curricula accordingly (Research mission interview with MUAS, Germany).

3.2.3. Interdisciplinary approaches

As noted in the previous chapter, the complexity of new digital technologies and their very varied applications in numerous economic sectors mean that interdisciplinary learning is crucial. Interdisciplinary programmes are becoming increasingly common in several of the countries examined in this study.

There is a long tradition, for example, of multidisciplinary study programmes in Germany, where combined study courses in business informatics have been taught since the 1990s. Particular focus is being placed on training ICT experts who can support companies' digital transformation. A number of innovative combined study programmes have also been launched, primarily in cooperation with university media, health, and engineering departments. In Canada, areas in which demand for ICT specialists is expected to increase significantly include health and biotechnology, agritech and fintech. In Singapore, a cross-disciplinary approach that allows students to develop crucial digital skills is increasingly being adopted in the legal and financial fields.

Developments in AI are also fostering demand for interdisciplinary approaches (Research mission interview with Tsinghua University). AI Singapore, a national programme to boost Singapore's AI capabilities, has established the AI Apprenticeship Programme. The goal of this Programme is to target, train and prepare local Singaporean AI talent to take up positions in the labour market. Students on the Programme, which is full time and lasts nine months, are from a variety of academic backgrounds and all have some prior knowledge of AI and machine learning (Research mission interview with AI Singapore).

The examples above show that some efforts are being made to promote an interdisciplinary approach in ICT education at post-secondary level. However, a more coordinated approach and additional investments are likely to be required in order to increasingly develop these approaches and further strengthen students' interdisciplinary skills.

1 For further information, see: www.iiitm.ac.in/index.php/en/academics-final/academic-programs/integrated-post-graduate-ipg/65-post-graduate-m-tech

▶ 3.3. Continuous training

Given the high speed of technological development, ICT specialists participate more frequently in continuous training than specialists in other fields. In Germany, for example, companies provide more continuous training for ICT specialists than for those in other occupations, and ICT workers invest considerable time in pursuing free online courses. Continuous training, which can take various formats and can vary in duration, encompasses, inter alia, informal workplace learning, self-directed online training, structured company-based training and training to obtain certificates.

As mentioned in the section above on lifelong learning, Canada, China, Germany and Singapore have all implemented policies to promote continuous or adult learning. For example, the Government of Singapore has implemented a robust policy to promote skills development for the Singaporean workforce and is investing substantial resources in continuous education and training (Research mission interview with Institute for Adult Learning, Singapore). Main initiatives include on-the-job training programmes, immersive programmes for older workers and programmes focused on the skills workers need to work effectively with new technologies.

In addition to government initiatives, social partners also facilitate the provision of continuous training. In Singapore and in China, for example, workers' organizations organize continuous training courses for workers. In Canada, ICTC, in partnership with Microsoft Canada, has established a programme to bridge the digital divide for job seekers looking for an opportunity to diversify their professional experience.

While continuous training programmes are available at many large companies, organizing and financing continuous training is more challenging for small and medium-sized enterprises, which may not have a designated human resources department or a long-term strategic plan for skills development (Research mission interviews).

Overall, the responsibilities of workers, employers and governments in terms continuous training varied among the seven countries. Research from Canada, China, Germany and Singapore found that training costs tend to be borne by both the individuals receiving training and companies. Although governments have enacted policies to promote the upskilling and reskilling of workers, those policies tend to focus on specific groups of individuals or companies.

4

Promoting the creation of inclusive and diverse ICT occupations

4.1. Gender equality

As mentioned above, women comprise only roughly a third of all ICT specialists in the seven countries examined in this study. Encouraging more women to pursue careers in ICT and investing in measures to ensure inclusive employment opportunities and gender-responsive workplaces can have large benefits. For example, increasing the number of women employed in the ICT sector can help to reduce the gender pay gap.[1]

The European Institute of Gender Equality estimates that encouraging more women to pursue careers in science, technology, engineering and mathematics (the so-called STEM subjects) "would lead to economic growth, with more jobs (up to 1.2 million by 2050) and increased GDP over the long-term (up to 820 billion Euros by 2050)".

The low proportion of women in ICT occupations is due to several mutually reinforcing factors, including the following:

- Gender stereotypes and social norms regarding the role of women in society, which can have a negative impact on girls at a very early age, including when they are in pre-school. As a result, fewer women tend to enrol in ICT-related study fields;
- The underrepresentation of women in ICT programmes at higher education institutions and in ICT occupations; and
- Similar to occupations in other sectors, women and men working in ICT occupations are faced with lack of flexibility in managing work and life and a lack of childcare facilities.

Unconscious gender bias i.e. unintentional and automatic mental associations based on gender, stemming from traditions, norms, values, culture and/or experience may also impede the participation of women in ICT occupations, for example, due to biases in recruitment and promotion (ILO, 2017).

4.1.1. Women in ICT education

As certain social norms and stereotypes can negatively affect girls as early as the pre-school educational stage, it is crucial that steps are taken at an early age to encourage young girls to consider careers in the field of ICT. Evidence from Germany indicates that girls' interest in ICT decreases with age. For example, the ratio of girls to boys taking part in informatics youth competitions is almost equal during school grades one to four, but decreases with each passing school grade until the share of girls taking part in those competitions at the high school level is only 28 per cent (Bundestag, 2018). Girls may, moreover, become demotivated and their initial interest may diminish due to the dominance of boys in computer courses, competitions, relevant study classes and activities.

Most of the countries examined in this study have launched initiatives to encourage young women to study ICT-related subjects. For example, the

1 As asserted by European Institute of Gender Equality

MINT-Mädchen (STEM girls) project in Germany includes a scouting phase where girls who are interested in STEM subjects are identified at schools. Those girls then receive coaching that includes technical input and coaching about gender-typical role perceptions and behavioural patterns. Meanwhile teachers and professors at universities receive support regarding gender-sensitive STEM teaching. In India, the Government has introduced quotas for women students at all Indian Institutes of Technology. The quota was set at 14 per cent in 2017-2018 and was increased to 20 per cent in 2020. The introduction of quotas has helped increase the share of women studying at Indian Institutes of Technology from 8 per cent in 2016 to 18 per cent in 2018.

An example of a programme that promotes digital literacy among young women and builds their confidence is the Canada Learning Code. Statistics have revealed that 67 per cent of the women and girls who participate in the Learning Code programme feel more comfortable with coding and technology, and that 81 per cent of young people who complete a Canada Learning Code course wish to learn more about those subjects.[2]

4.1.2. Obstacles to career development for female ICT specialists

Gender discrimination may impede the career paths of female ICT specialists, while research on women working in STEM fields has revealed the existence of significant gender pay gaps in STEM fields, that men in senior positions in the sector tend to be younger than women in similar positions, and that women typically exit the sector after five years (Gupta, 2019). In Canada and Germany, although women are underrepresented at all seniority levels, the proportion of women in managerial positions remains especially low (Brookfield Institute, 2019; Bitkom, 2019a). Some progress has been achieved, however. For example data show that, in Singapore, the proportion of women serving as board members has recently increased across all industries, including the ICT sector.

Furthermore, numerous initiatives have been launched to enhance the gender balance in the workplace. One example is the Women in Technology Special Interest Group (WiT@SG), established by the Singapore Computer Society, which aims to increase the number of women in the technology sector through the creation of a platform for professional women to connect, learn and lead in the industry.

However, despite a plethora of programmes to increase the participation of women in ICT education and occupations, women remain underrepresented in the sector. A more coordinated and targeted approach is required to promote inclusive employment and gender-responsive workspaces. This could include, for example, addressing negative stereotypes in early childhood education, promoting measures that encourage more women to study STEM subjects and pursue careers in ICT, by raising their awareness of potential ICT careers, improving the ICT working environment for women in the ICT sector, addressing unconscious bias in the industry, and promoting professional and role model networks.

4.2. Mid-career and older workers

Given the anticipated gaps and shortages, mid-career and older workers represent a large untapped talent pool that can be reskilled and upskilled.

With the exception of Singapore, the majority of the seven countries have not yet launched programmes that focus specifically on mid-career and older workers in the field of ICT. Initiatives such as the Singaporean Professional Conversion Programmes provide opportunities for older workers both with and without backgrounds in ICT (see Box 2).

Box 2: Skills initiatives for mid-career and older workers in Singapore

Designed to help experienced workers move into high-demand industries, Professional Conversion Programmes provide industry professionals, managers, and executives with skills training to help them change career, obtain jobs in a new field and progress further in their careers. Several Professional Conversion Programmes, including the Professional Conversion Programme for Data Analysts and the Professional Conversion Programme for Full Stack Software Developers, place particular emphasis on ICT skills. Participants in a Professional Conversion Programme receive up to 90 per cent of their monthly salary and assistance with course fees.

Sources: IMDA and Workforce Singapore.

2 For further information, see: www.canadalearningcode.ca/about-us

▶ 4.3. Migrant workers

Globally, the migration of ICT specialists has risen over the past three decades. International competition to attract highly-skilled ICT specialists has increased as a result of the digitalization of global economies and the increasing use of ICT. Migrants can help address short-term skills shortages and can therefore generate significant benefits for destination countries. Respecting the rights of migrant workers and families and ensuring that international labour standards are upheld are crucial in the management of labour migration.[3]

To address skills gaps and shortages in the ICT sector, Canada, China, and Germany have introduced special visa programmes to facilitate the international labour migration of ICT specialists (Box 3).

Visa applications can be expensive and take considerable time to process. Those costs and processing times may deter individuals from applying for visas and deter companies from recruiting abroad. Other barriers faced by migrating ICT specialists may include the failure of destination countries to recognize qualifications that they have obtained abroad and language barriers. A survey of highly-skilled Indian migrants working in four European countries found that more than one fifth of respondents were over-qualified for their present job. The most frequent reasons for feeling overqualified included not working within their field of expertise and not being able to transfer Indian degrees and work experience to Europe.[4]

Mutual agreements on recognition of study programmes are key to facilitating further migration. An important mutual recognition framework relevant to the ICT sector is the International Engineering Alliance

▶ Box 3: Special visa programmes for highly-skilled foreign ICT specialists

a. Canada

The **Global Talent Stream** initiative is aimed at attracting highly-skilled individuals to work in the country's tech industry by fast tracking work permit approvals. It enables the federal Government to issue a work permit in less than two weeks. More than 1,000 Canadian companies have used the Global Talent Stream to hire more than 4,000 highly-skilled foreign workers to address short term skills needs. The programme has received very positive feedback from employers and applicants and was made permanent in March 2019. Since then, recruiters for Canadian high-tech companies have noted a surge of interest from foreign high-tech workers.

b. China

In 2019, China introduced the **National High-end Foreign Expert Recruitment Plan** in order to attract high-level foreign experts in priority fields with a view to fostering innovation in science and technology. The Plan not only focuses on senior managers and entrepreneurs, but also on young highly-skilled individuals in areas of the economy affected by skills shortages. Those recruited under the Plan are encouraged to remain in China long-term.

c. Germany

The German Parliament recently adopted the **Skilled Labour Immigration Act**, which entered into force on 1 March 2020. The new Act eases the immigration of skilled workers with a recognized tertiary or vocational education qualification to Germany. An exception is made for ICT specialists, however, who can take up employment even without a formal qualification if they have at least three years' work experience, a monthly income of at least €4,020 (US$ 4,468), and a conciliation agreement with the Federal Ministry of Labour and Social Affairs (BMAS).

Sources: ESDC, 2019; China Innovation Funding, 2019; German Federal Ministry of the Interior, n.d.

3 The Global Compact for Safe, Orderly and Regular Migration covers all aspects of international migration, including labour migration. Additionally, the Migration for Employment Convention (Revised), 1949 (No. 97) and Migration for Employment Recommendation (Revised), 1949 (No. 86) along with the Migrant Workers (Supplementary Provisions) Convention, 1975 (No. 143) and Migrant Workers Recommendation, 1975 (No. 151) contain provisions that guarantee basic protections to migrant workers.

4 The sectors selected for this survey were ICT; finance and management; biotechnology and pharmaceuticals; and academia within the fields of science and technology. These sectors were facing skills shortages in the four selected countries (France, Germany, The Netherlands and Switzerland)

Washington Accord, which has been signed by 20 countries, including Canada, China, India, Japan, Singapore, the United Kingdom and the United States of America. The Accord facilitates the mobility of professional engineers, including in the area of ICT. Countries often enter bilateral labour migration agreements, not only to enhance migration governance, but also to address skills gaps and shortages. To facilitate that process, the Guidelines for skills modules in bilateral labour migration agreements were published by ILO in 2020.

Research interviews in Indonesia and Thailand highlight that a lack of English language skills is a major impediment for ICT specialists aspiring to move abroad. In addition to English language skills, knowledge of the local language of migrants' destination countries is often very useful. In Germany, for example, although many workplaces do not require ICT specialists to speak or understand German, a knowledge of German can facilitate migrants' integration into German society.

Pre-arrival and post-arrival services for migrants are also crucial. Integrating into the labour market can take several months following arrival. Pre-arrival and settlement services can help shorten that period and enable potential migrants to strengthen their employability while still in their country of origin. Pre-arrival services include job-readiness assessments, upskilling courses and job-search counselling. Canada, for instance, provides a wide range of support services and programmes for immigrants and refugees that promote their full participation in economic, social and cultural life. In Germany, the Federal Employment Agency (BA) has established the Zentrale Auslands- und Fachvermittlung (ZAV) (Central International Intermediation Service), which provides counselling and job placement services to skilled migrants, including ICT professionals.

Finally, the COVID-19 pandemic is currently having a significant impact on the migration of highly-skilled workers. Indeed, shortages of highly-skilled workers may worsen due to ongoing international travel restrictions, while research from Germany reveals that the information and data sectors are among those economic sectors that have been particularly affected by the crisis (KfW, 2020).

4.3.1. Return migration

The immigration of ICT specialists is generally viewed positively in destination countries, as it leads to a "brain gain" and helps address skills shortages. From the viewpoint of countries of origin, a corresponding "brain drain" may be an issue of some concern. In recent years, however, the debate has shifted towards looking at what has been dubbed "brain circulation", a situation in which ICT specialists who have worked abroad bring innovative skills back to their country of origin when they return to take up residence there once more. The growth of the Indian ICT sector, for example, has been driven in part by the return of large numbers of Indian ICT specialists from abroad. The temporary nature of many contracts offered to workers abroad has also reinforced the phenomenon of return migration. Due to their international work experience, many companies operating in India are very keen to hire returning migrants. To support return migration, the Ministry of External Affairs, Division of Overseas Indian Affairs has established Overseas Indian Centres Abroad in Abu Dhabi, Kuala Lumpur and Washington, D.C. with a view to reaching out to Indian diaspora populations and engaging with them to create knowledge networks (Testaverde and others, 2017).

Return migration is also a priority for China and Singapore. For example, Zhaopin Ltd., one of the largest recruitment agencies in China, contacts Chinese students studying abroad to make them aware of job offers in China, as their experience abroad and their adaptability are seen as particularly advantageous in the rapidly changing ICT industry (Research mission interview with Zhaopin Ltd., China).

In order to attract highly-skilled ICT specialists, companies often offer high salaries and attractive employee benefits, in addition to bonuses and stock options (Research mission interview with TAOLE, China). Government agencies in Singapore have also increased their outreach efforts in recent years to encourage expatriate Singaporeans to take up employment in their home country. In addition to outreach, Singaporean citizens residing outside Singapore are eligible to participate in the Tech Immersion Placement Programme. As an incentive, course fees paid by overseas participants in the Programme are reimbursed if they submit documentation showing that they have completed a post-training job placement in Singapore.

Further research is required, however, to assess the effectiveness of the aforementioned measures and to identify the most effective combination of policies to attract and retain returning migrants.

4.3.2. Retaining international students

The migration of students is a key path for accessing a country's labour market as it facilitates access to internships during studies, equips students with a formal education that employers can easily identify and trust, and gives students in-depth knowledge of how a country's labour market functions. According to the Canadian 2016 Census of Population, for example,

43 per cent of all immigrants working in the ICT sector had studied in Canada. It is also in the interests of destination countries to retain international students after graduation to address skills shortages.

The number of international students studying ICT-related subjects is higher than the numbers studying other subjects. In the 2016-2017 academic year, there were 186,267 students from India enrolled at universities in the United States of America. More than one third of those students were studying mathematics and/or computer science (Institute of International Education, 2018). In Germany, the proportion of international students studying ICT-related subjects was double the figure for most other subjects.

Higher education institutes in India, Indonesia and Thailand collaborate with partners abroad to ensure that their students gain international experience. For example, the Swiss German University (SGU) of Indonesia has introduced a unique internship programme in which SGU students must complete two mandatory internships, one locally and one abroad. The programme fosters close cooperation between graduates and the foreign companies they intern at. In addition, some students can qualify to receive a degree from one of SGU's partner universities in Germany or Switzerland.

Key findings and possible policy responses

Findings from seven countries examined in the study – Canada, China, Germany, India, Indonesia, Singapore and Thailand – indicate that the ICT sector and other sectors of the economy are facing a shortage of ICT workers with the right combination of soft and technical skills. Furthermore, the ICT sector in the seven countries is growing more rapidly than other economic sectors, which in turn means that demand for skilled workers will continue to increase.

ICT specialists account for a significant and increasing share of the labour force. For example, ICT specialists accounted for 7 per cent of total employment in Canada. They have higher levels of education than the average worker, earn higher than average wages, and are likely to be younger and male. Fierce competition for these specialists has led to an increase in migration.

The share of foreign ICT specialists has been rising steadily in Canada, Germany and Singapore. India is one of the world's most important emigration countries for ICT specialists. While large-scale emigration has led to concerns about a potential 'brain drain', there is growing evidence of 'brain circulation', in which significant return migration has positive effects for both origin and destination countries.

Based on the evidence presented in the above chapters, Box 4 outlines 10 possible policy responses that could help inform dialogue among governments, employers' and workers' organizations and facilitate the formulation of effective policies to advance decent work opportunities for more women and men in the digital economy.

Box 4: 10 possible policy responses

1. Invest in a skill anticipation system to enhance understanding of current and future skills needs

Skills shortages and other skills mismatches were detected in the digital economies of all seven countries. This means that the skills currently offered by employed workers and those seeking employment do not match the skills that are required by employers. That phenomenon undermines economic growth and creates inefficiencies because workers themselves or broader society has invested in the development of skills that are not required in the labour market, while companies continue to struggle to find workers with the particular skills they require.

It is thus vital to establish a skills anticipation system that can help relevant stakeholders assess whether countries' education and training systems are providing skills needed by companies, whether workers possess skills that will allow them to adapt to economic, technological and organizational changes in the future, and whether employers are upskilling and reskilling their workers appropriately.

2. Increase investment in post-secondary education institutions and teaching staff

Although the number of students studying ICT-related subjects in Canada, China, Germany and Singapore is increasing, the number of ICT graduates is still inadequate to keep pace with growing labour market needs. In India, Indonesia and Thailand, the number of graduates at the bachelor's degree level is currently sufficient to meet the demand of the labour market, although many of those graduates still lack many critical skills needed by employers. Moreover, educational and training institutions in those countries are failing to produce adequate numbers of master's and doctorate level graduates in ICT-related subjects. Steps should thus be taken to increase investments in post-secondary education to ensure that there is a sufficient number of ICT graduates at all degree levels.

Another challenge to scaling up ICT education at higher education institutions and vocational schools is the shortage of suitably qualified academic teaching staff. Continuous training for teaching staff should be provided to ensure that teaching methodologies and course syllabuses keep up to date with rapid technological change so that students are well prepared for the future of work.

▶ Box 4: 10 possible policy responses *(cont.)*

3. Encourage more women to study science, technology, engineering and mathematics (the so-called STEM subjects) and pursue careers in the field of ICT.

Women comprise approximately a third of all ICT specialists in the seven countries examined in the study. The low proportion of women in ICT occupations may be due to several mutually reinforcing factors, including: (i) gender stereotypes and social norms regarding the role of women in society, which can have a negative impact on girls at a very early age, including when they are in pre-school. As a result, fewer women tend to enrol in ICT-related study fields; (ii) the underrepresentation of women in ICT programmes at higher education establishments, and in ICT occupations, and; (iii) Women and men working in ICT occupations are faced with lack of flexibility in managing work and life and a lack of childcare facilities.

Policy measures adopted by countries include the provision of vocational orientation and guidance, coding competitions, women's awards, the identification of female role models, and the establishment and strengthening of women's professional networks. However, current low female participation rates in the ICT field suggest that further coordinated and targeted efforts are required to encourage more women to study STEM and ICT-related subjects and consider careers in ICT, and address barriers to their career development.

4. Tackle the skills gaps between skills acquired at universities or vocational training institutions and skills demanded by industry

Skills gaps are prevalent in the ICT sector, including among recent graduates. This makes the transition from higher education to the workplace difficult and graduates often require several months of on-the-job training. To address these gaps, companies, industry associations and sector councils are often consulted during the curriculum development process. However, further work is required to close existing gaps.

In this regard, work-based learning is now widely recognized as an important tool for imparting both technical and soft skills. Internships have been integrated into numerous university curricula in tertiary education and are often mandatory at institutes of higher education in Canada, China and Germany. Higher education institutes in Singapore do not have a mandatory work-based learning component for all programmes but students do have the opportunity to participate in internships. In India, Indonesia and Thailand, internships are viewed as the primary means by which students can obtain practical experience. However, employers and employers' organizations have noted that further work-based learning is still required.

5. Increase the focus of education and training on soft skills

It is widely acknowledged that soft skills have become increasingly important for ICT specialists. For example, developing and using technologies requires critical, analytical and creative thinking, and problem solving while coping with technological change requires the ability to learn and flexibility. Furthermore, working in ICT companies also requires understanding organization of work and maintaining client relations which requires soft skills such as leadership, communication and teamwork.

Surveys conducted in several of the seven countries showed that employers often find it difficult to recruit employees with both technical and soft skills.

To address the increasing demand of soft skills, higher education institutions have started to integrate soft skills into their curricula. However, there is still scope for further efforts in that regard, including at earlier stages of education.

6. Promote interdisciplinary approaches to skills development

Digital technologies are transforming all sectors of the economy. In several countries, more than half of the ICT specialists in the digital economy work in sectors other than the ICT sector. In Canada, for example the areas in which demand for ICT specialists is expected to increase most significantly include health and biotechnology, agritech and fintech.

There is increasing demand in other economic sectors for skills in areas such as AI, cloud computing, big data and cybersecurity, as well as in business intelligence. Workers with knowledge of specific programming languages are also highly sought after. The ability to work in interdisciplinary fields and some knowledge of other study fields is also becoming increasingly important as technological complexity increases and

Box 4: 10 possible policy responses *(cont.)*

innovative digital technologies are adopted across a wide range of sectors and fields. It is therefore crucial that higher education institutions adopt interdisciplinary approaches, for example by setting up combined study courses and by promoting interfaculty teaching and research exchanges.

7. Invest in effective lifelong learning systems and continuous training in the field of ICT

As the demand for skills evolves, a comprehensive human-centred approach to lifelong learning will be crucial in helping workers adjust to rapid change. Efforts must be made to address the high social costs of rapid change while maximizing its benefits. Lifelong learning in relation to ICT has the potential to facilitate and accelerate digital transformation, support national innovative capacity, facilitate occupational mobility, respond to challenges arising from demographic change, and provide equal access to skills development. Although Canada, China, Germany and Singapore have formulated policies and strategies on lifelong learning, they largely focus on continuous training. It is important that comprehensive lifelong learning policies that equip workers with strong foundational skills are adopted, preparing both adults and children, including those in the earliest stages of their education, for a lifetime of learning.

There is a much greater need for continuous training for workers already working in ICT occupations. In India, for example, the Federation of Indian Chambers of Commerce and Industry estimates that between 60 and 70 per cent of the current IT workforce will require retraining because of changing skill requirements in the marketplace. ICT specialists can engage in continuous training by learning from co-workers, learning by doing and keeping up to date with industry trends. Companies should, moreover, expand their support for lifelong learning and continuous training, for example by establishing job-related educational incentives, giving greater attention to career path planning, and introducing on-the-job learning, inter alia, through job shadowing and job rotation.

8. Facilitate better recognition of foreign formal qualifications and work experience

Challenges related to the recognition of foreign qualifications often constitute a significant impediment to the migration of ICT specialists. In that regard, a survey of highly-skilled Indian migrants working in four European countries found that more than one fifth of respondents were over-qualified for their present job. The most frequent reasons for feeling overqualified included not working within their field of expertise and not being able to transfer Indian degrees and work experience to Europe.

Access to certain labour markets is dependent on the legal recognition of skills and qualifications, and the procedures that migrants must follow to obtain recognition of qualifications they obtained prior to their arrival in their destination countries are often onerous and time consuming. Recognition of qualifications, even if not legally required, can sometimes be useful if it increases the trust of potential employers in credentials obtained abroad. Mutual agreements on recognition of study programmes and strategies to attract international students may help address that challenge and facilitate further migration.

9. Simplify visa application processes and provide support for migrant ICT specialists to facilitate their integration into their new working and living environments.

Visa applications can be expensive and take considerable time to process. Those costs may deter individuals from applying for visas and deter companies from recruiting workers from abroad. Canada, China, Germany and Singapore have recently introduced measures to facilitate the immigration of ICT specialists. Further steps are needed, however, to streamline that process.

Following their arrival in their destination country, migrants can take several months to integrate into the labour market. Pre-arrival and settlement services can help shorten this period and enable potential migrants to strengthen their employability while still in their country of origin. Pre-arrival services include counselling services, e.g. a job-readiness assessment, upskilling courses and job-search counselling.

Weak language skills can also impede migration. For example, research interviews in Indonesia and Thailand highlight that a lack of English language skills is a major impediment for ICT specialists aspiring to move abroad. In destination countries where the local language is not the working language, knowledge of the local language can be helpful. In Germany, for example, although many workplaces do not require ICT specialists to speak or understand German, a knowledge of German can facilitate migrants' integration into German society.

▶ Box 4: 10 possible policy responses *(final)*

10. Promote coordination among relevant ministries and authorities and strengthen social dialogue

Several ministries and government agencies, including ministries of labour and employment, education and industry, are involved in defining skills development and international labour migration policies and strategies to ensure decent work for employees in ICT-related occupations. In most cases, cooperation and coordination among these stakeholders are weak at regional, national and local levels. Strengthening coordination among those stakeholders could enhance the formulation, implementation and effectiveness of policies and further advance efforts to promote decent work in the digital economy.

Constructive social dialogue among tripartite constituents, namely governments, employers' and workers' organizations, can also play a crucial role in addressing challenges and leveraging opportunities in the field of ICT. Employers' and workers' organizations in the ICT sector are concerned, in particular, about issues related to skills development, working hours and mental health.

While employers' associations in the ICT sector are active in all seven countries, there are very few unions representing ICT sector workers. This may be due, inter alia, to ICT workers' relatively good working conditions, including their relatively high wages, and new forms of organizing work among ICT workers. Trade unions in the ICT sector have only recently been established in India and Indonesia in the wake of labour disputes in that sector. Representative and strong employers' and workers' organizations can play a key role in advancing opportunities for decent work for both women and men in the ICT sector.

References

Unless otherwise stated, all sources were accessed on 17 September 2020.

acatech (Deutsche Akademie der Technikwissenschaften) (2016). *Kompetenzen für Industrie 4.0. Qualifizierungsbedarfe und Lösungsansätze/Skills for industrie 4.0: Training requirements and solutions*. acatech Position Paper. Available at: www.acatech.de/publikation/kompetenzen-fuer-industrie-4-0-qualifizierungsbedarfe-und-loesungsansaetze/

Agahari, Wirawan (2017). *Peluang dan Tantangan Ekonomi Digital di Indonesia.* Jakarta: Centre for Innovation Policy and Governance (CIPG). Available at: cipg.or.id/tantangan-ekonomi-digital-indonesia/

Akella, Bhavana (2019). Shortage of skilled IT workforce looms over India: NASSCOM. *Indo-Asian News Service (IANS),* 18 February. Available at: www.sify.com/finance/shortage-of-skilled-it-workforce-looms-over-india-nasscom-news-corporate-tcsqV1hchicec.html

Bitkom e.V. (2019a). *IT-Fachkräfte: Nur jeder siebte Bewerber ist weiblich* [IT specialists: only one in seven applicants is female] Press release, 6 March. Available at: www.bitkom.org/Presse/Presseinformation/IT-Fachkraefte-siebte-Bewerber-weiblich

— (2019b). *Der Arbeitsmarkt für IT-Fachkräfte.* Achim Berg, Bitkom-Präsident , Berlin, 28. November. Available at: www.bitkom.org/sites/default/files/2019-11/bitkom-charts-it-fachkrafte-28-11-2019_final.pdf

— (n.d.). *Frauen in der IT* [Women in IT]. Available at: www.bitkom.org/Themen/Bildung-Arbeit/Frauen-in-der-Digitalwirtschaft

Brookfield Institute (2019). *Who are Canada's Tech Workers?* Toronto, Canada. Available at: brookfieldinstitute.ca/wp-content/uploads/FINAL-Tech-Workers-ONLINE.pdf

Bundestag (2018). *Drucksache 19/5057: Frauen in der Informatik – Ein Blick in die Bildungskette: Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten Dr. Anna Christmann, Ulle Schauws, Beate Walter-Rosenheimer, weiterer Abgeordneter und der Fraktion BÜNDNIS 90/DIE GRÜNEN – Drucksache 19/4426* [Vol. 19/5057: Women in computing – a look into the training track. Response of the Federal Government to the written question from members of parliament Dr. Anna Christmann, Ulle Schauws, Beate Walter-Rosenheimer, further members of parliament and the Bündnis 90/Green faction. Vol. 19/4426]. 12 October. Available at: dip21.bundestag.de/dip21/btd/19/050/1905057.pdf

Cameron, Alicia and S. Faisal (2016). *Digital Economy Talent Supply: Immigration Stream*. Ottawa: Information and Communications Technology Council. Available at: www.ictc-ctic.ca/wp-content/uploads/2016/09/Digital-Economy-Supply_The-Immigration-Stream.pdf

Cutean, Alexandra and others (2019). *Canada's Growth Currency: Digital Talent Outlook 2023*. Ottawa: ICTC. Available at: saskchamber.com/isl/uploads/2020/05/ICTC-Canada-Growth-Currency-2019-Report1.pdf

Ernst and Young (2015). *Reining in sexual harassment at the workplace in India. A survey by Forensic & Integrity Services*.

Gupta, Namrata (2019). *Women in Science and Technology: Confronting Inequalities*. New Delhi: Sage Publishing.

ICTC (2016). *Digital Talent: Road to 2020 and beyond: A national strategy to develop Canada's talent in a global digital economy*. Ottawa.

— (2019). *The next talent wave: Navigating the digital shift – Outlook 2021*. Ottawa.

— (2019). *Digital Economy Annual Review 2018.* Ottawa.

ILO (2017). *Breaking barriers: Unconscious gender bias in the workplace*. Geneva

ILO (2019). *Skills shortages and labour migration in the field of information and communication technology in India, Indonesia and Thailand.* Geneva. Available at: www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_710031.pdf

— (2020a). *Skills shortages and labour migration in the field of information and communication technology in Canada, China, Germany and Singapore.* Geneva.

— (2020b). *Guidelines for skills modules in bilateral labour migration agreements*. Geneva. Available at: www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---migrant/documents/publication/wcms_748723.pdf

India, Ministry of Electronics & Information Technology (MEITY) (2017). *Fact Sheet of IT & BPM Industry.* Available at: www.meity.gov.in/content/fact-sheet-it-bpm-industry

Infocomm Media Development Authority (2018). *Annual Survey on Infocomm Manpower for 2017*. Singapore. Available at: www.imda.gov.sg/-/media/imda/files/industry-development/fact-and-figures/infocomm-survey-reports/infocomm-media-manpower-survey-2017-public-report.pdf?la=en

— (2019). *Annual Survey on Infocomm Manpower 2018*. Singapore. Available at: www.imda.gov.sg/-/media/imda/files/industry-development/fact-and-figures/infocomm-survey-reports/20190208-infocomm-media-manpower-survey-2018-public-report.pdf

Innovation, Science and Economic Development Canada (2019). *2018 Canadian ICT Sector Profile: Automotive, Transportation and Digital Technologies Branch*. Ottawa. Available at: www.ic.gc.ca/eic/site/ict-tic.nsf/vwapj/ICT_Sector_Profile2018_eng.pdf/$file/ICT_Sector_Profile2018_eng.pdf

International Engineering Alliance. (n.d.). *25 Years of the Washington Accord.* Available at: www.ieagreements.org/accords/washington/

KfW (2020). *Corona-Krise und Fachkräftemangel bremsen das Wachstum*. Available at: www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-2020/Fokus-Nr.-293-Juni-2020-Corona-Krise-und-Fachkraeftemangel.pdf

Lehdonvirta, Vili (2018). Flexibility in the gig economy: managing time on three online piecework platforms. In *New Technology, Work and Employment*, vol. 33(1), pp. 1-93. Available at: onlinelibrary.wiley.com/doi/abs/10.1111/ntwe.12102

National Skill Development Corporation (NSDC) (2011). Human Resource and Skill Requirements in the IT and ITES Industry Sector: study on mapping of human resource skills gaps in India until 2022. Available at: glpc.guj.nic.in/pride/ADMINUI/Resourcefiles/Res220IT%20ITES%20Industry.pdf

OECD (2016). *Education in China. A snapshot*. Paris: OECD Publishing. Available at: www.oecd.org/china/Education-in-China-a-snapshot.pdf

— (2019). *OECD Economic Surveys: China 2019*. Paris: OECD Publishing. Available at: www.oecd-ilibrary.org/economics/oecd-economic-surveys-china-2019_eco_surveys-chn-2019-en

SGTech (2019). *Annual Business Survey 2018/19*. Singapore.

Singapore, Ministry of Education (2018). *Education Statistics Digest 2018.* Available at: www.moe.gov.sg/docs/default-source/document/publications/education-statistics-digest/esd_2018.pdf

Singapore, Ministry of Manpower (n.d.). *What the gender pay gap is not telling you*. Online tool. Available at: stats.mom.gov.sg/genderpaygap/index.aspx

— (2018). *Summary Table:Income*. Web page. Available at: stats.mom.gov.sg/Pages/Income-Summary-Table.aspx

— (2019). Distribution of Resident Population by Labour Force Status, Age and Sex, 2008 – 2018" (June) in *Labour Force in Singapore 2018*. Available at: stats.mom.gov.sg/Pages/Labour-Force-In-Singapore-2018.aspx

Singapore, Ministry of Manpower Research and Statistics Department (n.d.). *Labour Force Survey*. Available at: stats.mom.gov.sg/lfs/index.aspx

Singapore, Ministry of Trade and Industry (2019). *Economic Survey of Singapore 2018.* Available at: www.mti.gov.sg/-/media/MTI/Resources/Economic-Survey-of-Singapore/2018/Economic-Survey-of-Singapore-2018/FullReport_AES2018.pdf

Statistics Canada (2016). *Census data table 98-400-X2016251.* Available at: www150.statcan.gc.ca/n1/en/catalogue/98-400-X2016251

Statistics Canada (2020). StatCan Covid-19: Data for insights for a better Canada. Available at: www150.statcan.gc.ca/n1/pub/45-28-0001/452800012020001-eng.htm

Testaverde, Mauro and others (2017). *Migrating to Opportunity Overcoming Barriers to Labor Mobility in Southeast Asia*. Washington, D.C.: World Bank. Available at: openknowledge.worldbank.org/handle/10986/28342

Thailand Board of Investment (2017) *Thailand's Digital Economy & Software Industry*. Available at: cebitasean.com/downloads/BOI-Brochure2017-DigitalEconomy-20170821.pdf

UNCTAD (2019). *Digital Economy Report 2019 - Value creation and capture: implications for developing countries*. New York. Available at: unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2466

Vogler-Ludwig, Kurt, Nicola Düll and Ben Kriechel (2016). *Arbeitsmarkt 2030 – Wirtschaft und Arbeitsmarkt im digitalen Zeitalter: Prognose 2016*. Bielefeld, Germany: W. Bertelsmann Verlag. Available at: www.ssoar.info/ssoar/bitstream/handle/document/52096/ssoar-2016-kriechel_et_al-Arbeitsmarkt_2030_-_Wirtschaft_und.pdf?sequence=1

Wheebox (2018). *India skills report 2018*. Available at: wheebox.com/india-skills-report-2018.htm

World Economic Forum (2020). *10 technology trends to watch in the COVID-19 pandemic*. Geneva. 27 April. Available at: www.weforum.org/agenda/2020/04/10-technology-trends-coronavirus-covid19-pandemic-robotics-telehealth/

Zika, Gerd and others (2019). *BMAS-Prognose „Digitalisierte Arbeitswelt" - Kurzbericht*. Forschungsbericht, 526/1K. Berlin: *Bundesministerium für Arbeit und Soziales* (BMAS). Available at: www.bmas.de/DE/Service/Medien/Publikationen/Forschungsberichte/Forschungsberichte-Arbeitsmarkt/fb526-1k-bmas-prognose-digitalisierte-arbeitswelt.html

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