CHAPTER 2
THE TECHNOLOGICAL REVOLUTION: WINNERS AND LOSERS

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KEY MESSAGES

- Highly skilled workers are benefiting the most from new technologies. Moreover, in many countries, productivity gains brought about by such technologies are largely being captured by a small number of dominant companies.
- Technological progress displaces workers, mainly through automation, but it also creates demand for new jobs. Job disruption – and, at times, destruction – is affecting mainly low-skilled and middle-skilled workers, contributing to job polarization and wage inequality.
- Technological innovations in sectors such as health and banking have far-reaching implications for equality. The potential of new technologies to foster sustainable development can only be realized, however, if everyone has access to and uses them.
- Proactive policies and supportive institutions can help ensure that technological dividends are broadly shared.

INTRODUCTION

The world is in the midst of rapid, revolutionary and often disruptive technological breakthroughs. Advances in biology and genetics, robotics and artificial intelligence, 3D printing and other digital technologies, including information and communication technologies (ICTs), are transforming economies and societies. These new technologies bring new opportunities, greater efficiency and can contribute to the achievement of the SDGs. They can help improve health and longevity, end hunger and enhance the quality of life.

FOR ALL ITS PROMISE, TECHNOLOGICAL INNOVATION IS CREATING WINNERS AND LOSERS

However, the rapid speed of current technological change brings new and urgent policy challenges for managing its impacts. While technology brings productivity gains, for instance, it can also erect hurdles for individuals and societies transitioning to new types of employment. For all its promise, technological innovation is already creating winners and losers. Highly skilled workers are benefiting more from new technologies than other workers, resulting in greater income and wage inequality.

Digital and communication technologies have also changed the nature of work: they allow workers more flexibility – not only in terms of the locations they can work from but in achieving better work-family balance. This agility extends to a wider choice of employers. More people now work part-time, as contractors or freelancers. Such non-standard work arrangements offer greater flexibility. However, they also leave workers in insecure employment and income situations, with weaker bargaining power compared to traditional workers belonging to labour unions. New technologies have also weakened unions and other labour market institutions. Skill-biased technologies have reduced the share of middle-skilled workers – once the backbone of labour unions – in the overall workforce. All of these factors affect wage inequality.

At the same time, digital innovation is opening opportunities in sectors such as health and finance. Advances in mobile technologies have eliminated the need for costly landlines and provided remote areas with access to communication networks and the Internet through mobile phones. This has made it possible for applications of digital technologies in health care and mobile banking to extend their reach to remote underserved areas as well as other poor communities.

These technologies can help drive development and create more inclusive societies. However, in order to harness their potential, Governments need to introduce policies and strategies to make new technologies accessible to all, particularly disadvantaged segments of society. If everyone had access and the capacity to use them, new technologies could help reduce inequality.

This chapter analyses the impact of new technologies on income and wage inequality. It argues that proactive policies and supportive institutions can help ensure that the dividends of technological change are broadly shared. Section A examines the impact of technological innovation on labour markets and income and wage inequality. Section B describes the extent of the technological divide and the opportunities that new technologies bring to sectors such as health and banking, with far-reaching implications for inclusion. The chapter concludes by considering the role of Governments in managing technological change and harnessing its potential for greater equality.

Technological change brings additional concerns for inequality, namely those associated with potential biases brought about by the use of algorithms in artificial intelligence. The increasing use of decision-making systems based on artificial intelligence in job recruitment and justice, for instance, can discriminate against certain population groups, including ethnic minorities, when based on biased historical data. These issues are explored in a recent United Nations report (United Nations, 2018b) and will not be examined in this chapter.

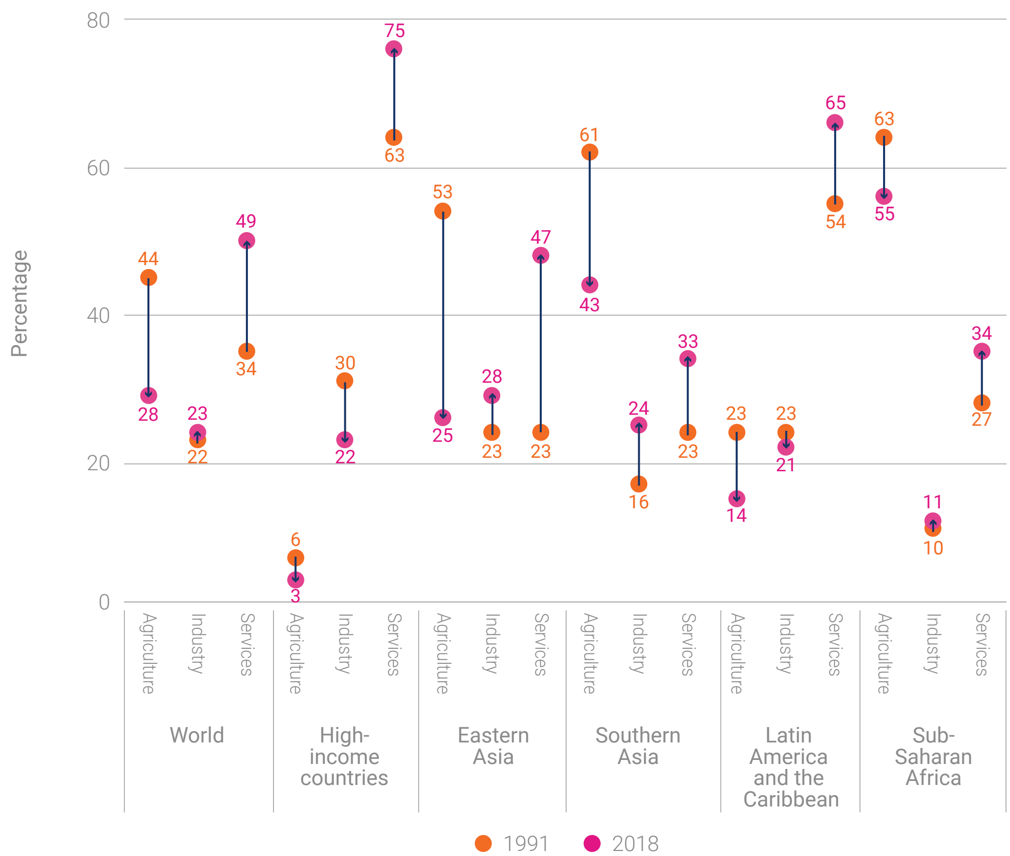
A. Technology, employment and inequality

Technological progress has been a primary driver of economic growth over the last two centuries. The past three industrial revolutions increased productivity per worker and per capita income, even though their full impact became visible only decades later (Bruckner and others, 2017). Industrial revolutions not only made the production of existing products more efficient, but they also created new products and services. This broadened the range of choices for consumers and producers. Higher incomes and more consumer choices have contributed to a higher quality of life in many parts of the world.

At the same time, technological progress prompted changes in sectoral employment. Specifically, the first industrial revolution encouraged shifts from the agricultural sector to manufacturing and, later, to the service sector. Developed countries completed the structural transformation away from agriculture early on, and many developing countries underwent a similar process later – often at a faster pace. Many least developed countries have not yet experienced this type of structural transformation, particularly those in sub-Saharan Africa, where most of the labour force is still employed in the agricultural sector. Ongoing technological innovation, however, will undoubtedly change the development paradigm, with implications for trade and global value chains in these countries. The traditional transition from agriculture to manufacturing may not be realized, and labour may move directly from agriculture to services.

The widespread use of machines and automatic devices has contributed to a decline in the share of workers employed in the agricultural sector at the global level. From 1991 to 2018, the share of agriculture in total employment declined by 16 percentage points at the global level, while remaining relatively unchanged in sub-Saharan Africa (see figure 2.1). On the other hand, the service sector gained importance in employment over the same period, now accounting for about 50 per cent of global employment. Rapid advances in digital technologies, particularly ICTs, have contributed to increases in the share of the service sector.

FIGURE 2.1
Total employment shares by sector and by region, 1991 and 2018 (percentage)



Source: Calculations based on data from ILOSTAT (November 2018).
Note: Regional averages are based on all countries in the region, including low-, middle- and high-income economies.

In the second half of the twentieth century, technological progress also changed the kinds of jobs demanded in developed countries. This progress intensified skill bias, and repetitive tasks previously carried out by low-skilled workers were replaced by machines and a smaller number of low- or high-skilled workers. This shift also contributed to increases in the college wage premium – that is, the wages of college graduates relative to the wages of high school graduates.

1. Labour-saving and skill-biased technologies

The emergence of new technologies is changing the nature of work. High-speed Internet ("broadband") offers workers and employers more flexibility and efficiency in the use of resources. On the other hand, the International Labour Organization argues that the same technologies could also erode workers' bargaining power and work-related benefits (Berg and others, 2018). Technological progress could also prompt the disappearance of certain jobs through automation and increase income inequality. This section assesses whether recent technological progress has contributed to widening income inequality by examining the impact of three related issues: (1) the types of technological progress that are increasing income and wage disparities, (2) labour-saving technological progress and the share of labour in national income, and (3) skill-biased technology and relative demand for high- and low-skilled workers.

THE EMERGENCE OF NEW TECHNOLOGIES IS CHANGING THE NATURE OF WORK

Many factors other than technology have contributed to income and wage inequalities. Advances in communication and transportation have made it possible for firms to establish and expand global value chains. Globalization, in turn, has influenced the choice of technologies, prioritizing those that are more profitable. The profit motive provides further incentive for firms to introduce more skill-biased or labour-saving technologies. This suggests that globalization and technological progress are reinforcing one another, widening income inequality in many countries – both developed and developing (Acemoğlu, 2003; Bruckner and others, 2017).

Changes in labour market institutions and liberal economic policies have also exacerbated inequality. Moreover, increased demand for goods and services that are produced using skill-biased or labour-saving technologies can explain a significant part of the growth of wage inequality since the second half of the twentieth century. A consensus on the specific dynamics of these factors, including technology, remains elusive.

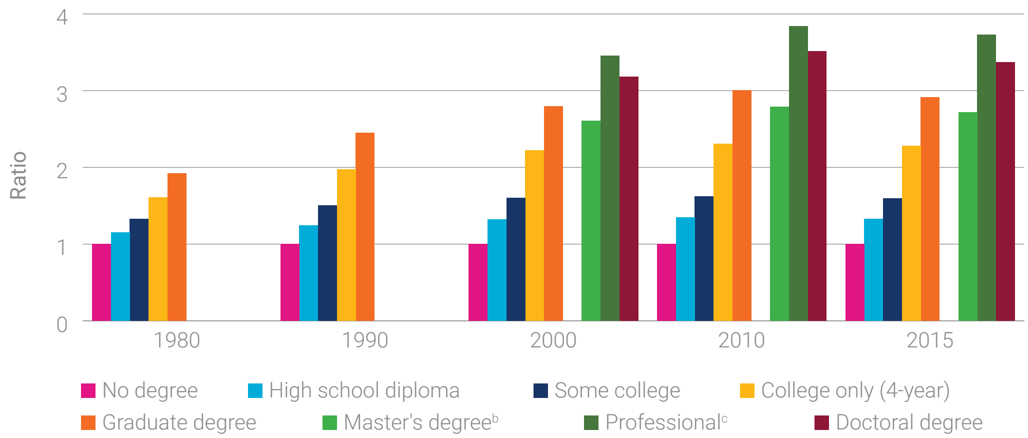
The technologies that are most relevant to the current debate about labour-market outcomes are skill-biased and labour-saving technologies. Skill-biased technologies increase the productivity and demand of high-skilled labour more than low-skilled labour. Labour-saving technologies, on the other hand, allow employers to produce the same amount of output with less labour. Today, progress in both skill-biased and labour-saving technologies typically involve digital technologies, which include ICTs, automation (which embodies artificial intelligence and machine learning technologies) as well as new service networks, organizations and management.

The use of labour-saving technologies affects the share of national income that goes to workers. Skill-biased technologies affect the composition of the labour force as well as the income that goes to workers with different skills. Skill bias comes into play with the technologies invented and diffused after World War II in developed countries, and their use has accelerated over the last three decades.[42]

Technological change in developed countries has been identified as skill biased. The wages of highly skilled workers – relative to those of low-skilled workers – have indeed been rising in the last decades, even while the supply of highly skilled (educated) workers has increased. All other things being equal, overall increases in education should reduce the impact of the "skill premium". Technological change has been recognized as an important factor in the rising skill premium (see figure 2.2).

[42] Historically, technologies have not been always skill biased. For example, interchangeable parts, a major technological advance in the nineteenth century in the United Kingdom, were designed to replace skilled workers (artisans) with weaving, spinning and threshing machines. The technologies were considered unskill biased (see Acemoğlu, 2003).

FIGURE 2.2
Wages by workers' level of education relative to workers with no degree, United States of America, 1980-2015[a]



Source: Calculations based on Valletta (2016), table 1.
Notes:
a. Wage premium is measured by the average hourly wage of workers in each educational group relative to workers with less than 12 years of education, labelled as "no degree".
b. Includes Master of Business Administration (MBA) and other master's degrees.
c. Includes Juris Doctor (JD), Doctor of Medicine (MD) and related degrees.

2. Share of labour in national income: impacts of labour-saving technology

Labour-saving technologies have been identified as one of the drivers of the declining income share of labour in both developed and developing countries (IMF, 2017a). Chapter 1 shows that the share of national income that goes to labour has declined in both developing and developed regions. Karabarbounis and Neiman (2013) estimate that the emergence of new technologies, particularly those related to ICTs, accounted for about half of the decline in the global labour share of income for 1975-2012.

Technological progress, proxied by a rapid decline in the price of investment goods relative to other goods, has contributed to and encouraged the shift away from labour and towards capital in production, particularly in developed countries.[43] The accelerated advance in ICTs, in general, and automation, in particular, underpins this decline. Lower prices of investment goods incentivize the employer to substitute capital – that is, the use of labour-saving technologies – for labour. If the production method, which includes not only technologies but also management and organizational arrangements, is flexible enough,[44] more capital is used to produce a unit of product, at the expense of labour. This reasoning is consistent with the experience of many developed countries.

Technological progress has also contributed to the emergence of one or two dominant firms in several industries. Autor and others (2017a) point out the role of firms such as Google, Apple, Facebook and Amazon in their respective industries in

[43] According to Karabarbounis and Neiman (2013), the relative price of investment goods declined by about 25 per cent from 1950 and 2010 in developed countries.
[44] In this case, the elasticity of substitution between labour and capital is said to be greater than one. Lawrence (2015) refutes the claim that elasticity is greater than one in the economy of the United States. He instead claims that elasticity is less than one and that technological progress is augmenting labour.

the declining labour share. The presence of these so-called superstar firms leads to a "winner-take-most" market concentration and increases the price markup over marginal cost, lowering the labour share of value-added in the industry. In fact, in the United States, market concentration has increased in some industries, and the industries with higher concentration have decreased their labour share (see also Autor and others, 2017b). Other possible factors that could explain the decline in labour share include increases in markups by monopolistic or oligopolistic firms and the share of economic profits (Karabarbounis and Neiman, 2013).

In developing countries, the share of labour in total income has declined for different reasons than in developed countries, even though new technologies still play a role. In conventional economic theory, developing countries are considered to have a comparative advantage in producing more labour-intensive products, while globalization would provide them with the opportunity to expand the production of such products, which would lead to a higher labour share in national income. Empirical evidence, however, suggests otherwise. Such evidence shows that it is difficult for developing countries to substitute capital with labour because of low elasticity, even when there is higher demand for labour. Moreover, advances in information technology and innovation in the transportation industry have geographically expanded global value (or supply) chains and deepened the supply and communication relations between headquarters offices and their suppliers and among suppliers in the value chains. Global value chains, in turn, have facilitated the off-shoring of capital-intensive production to developing from developed countries.[45] In general, off-shore tasks using new technologies are more capital-intensive than the average intensity in these host countries, contributing to a decline in the labour share.[46,47]

TECHNOLOGICAL PROGRESS HAS CONTRIBUTED TO THE SHIFT FROM LABOUR TO CAPITAL IN PRODUCTION – IMPLYING WORKERS ARE GETTING A SMALLER SHARE OF THE ECONOMIC PIE

It should be noted that the declines in labour share are largely due to intrasectoral (or within-industry) changes rather than to changes in the sectoral composition of the economy (or structural changes) (Karabarbounis and Neiman, 2013). If the changes were structural, the declining labour share would be attributed to shifts of workers from industries with higher labour-income shares (for example, finance and services) to those with lower shares (such as mining, transportation and manufacturing). This within-industry decline of the labour share, on the other hand, supports the role of labour-saving technology in the shrinking share of labour income at the national level. Karabarbounis and Neiman (2013) find that, with a few exceptions – namely, the economies of Puerto Rico and the Republic of Korea – by and large, changes in the within-industry labour share accounted for a significant portion of changes in the total labour share.

[45] According to the International Labour Organization, about 19 per cent of total employment in seven large developing countries (Brazil, China, India, Indonesia, Mexico, the Russian Federation and Turkey) involved jobs in global supply chains in 2013. See Kizu and others (2016).

[46] It should be noted that advances in ICT and transportation have also made it possible to expand global value chains in many parts of the world.

[47] More recently, increasing automation is argued to have led to reshoring (or *on-shoring*) of production – that is, the process of returning the production of goods back to the enterprise's home country. In theory, reshoring will force the host country to exploit its comparative advantage in labour-intensive production, thus leading to a higher labour share in national income. Yet it will take several years before any impacts of reshoring on labour share can be discerned.

3. Wage divergence: impacts of skill-biased technology

Widening wage inequality is a key contributor to the rise of income inequality. There are two possible channels through which recent technological progress has affected wage inequality, though they are not mutually exclusive. The first is the emergence of superstar managers, who innovate and capture a large share of the market, earning astronomical wages. The second channel is the so-called race between skills and technology: if the rate of technological progress is faster than increases in education, then the growing demand for highly skilled workers may result in higher wages for them (see Rotman, 2014). In fact, compensation paid to superstar managers and highly skilled workers has increased while that of middle- and low-skilled workers has stagnated or even declined, resulting in widening wage inequality, as explained in chapter 1.[48]

The term "superstars" originated in the television and motion picture industries; superstars significantly expanded the audiences for those in show business and sports, and their wages rose commensurately (Rosen, 1981). At present, chief executives of large corporations receive hefty compensation in the form of salaries, bonuses and, most importantly, stock options. According to the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO), the chief executive officers of S&P 500 companies received an average of $14.5 million in 2018, while the average production and non-supervisory worker earned about $40,000 that year.[49] The current era of new technologies is characterized by a small group of successful individuals and the enterprises they manage (see Brynjolfsson and McAfee (2014) and Autor and others (2017a)). The nature of the technology itself draws attention to their accomplishments and dramatically increases their rewards. The biggest economic winners are "those with the ideas behind new products and successful business models", not the conventional capital owners (Rotman, 2014, p. 10). In 2017, five technology and two financial companies were ranked among the 10 largest publicly traded companies in the United States. In 1967, only one technology company was among the top 10; the rest comprised oil and gas, film, automobile and telephone companies, all of which are capital intensive and tend to employ heavy machinery.

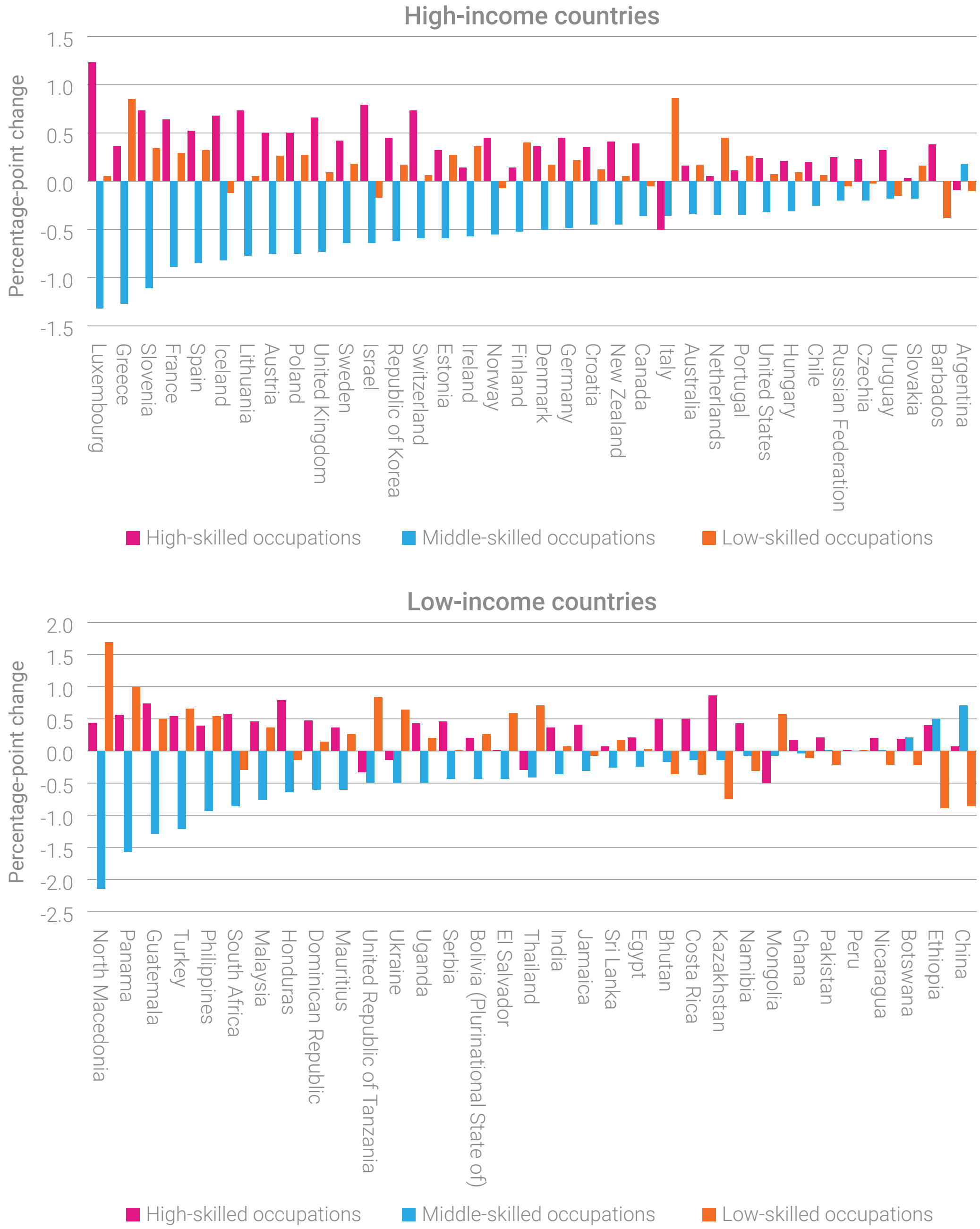
As described in the previous section, labour-saving technologies – particularly the automation of routine tasks – reduced the need for many production, sales, administrative and clerical jobs. The automation process began with advances in digital technologies in the 1980s. Now, artificial intelligence, machine-learning and robotics are the main drivers of technological progress that is expanding to a new domain of tasks and offers opportunities for automation in both manual and cognitive work.

There has indeed been a long-term reduction in jobs that are routine intensive. As shown in figure 2.3, the share of middle-skilled occupations – often administrative and sales-related –declined since the 1990s in almost all high-income countries and even in many low-income countries.

[48] Chapters 1 and 6 also point out that policy changes have contributed to the growing wage gap.
[49] AFL-CIO, "Highest-Paid CEOs", available from https://aflcio.org/paywatch/highest-paid-ceos.

FIGURE 2.3

Polarization of labour markets: changes in employment shares by skill level in high- and low-income countries, around 1995 and around 2015



Source: Calculations based on World Bank (2016b).

Note: High-skilled occupations include legislators, senior officials and managers, professionals, technicians and associate professionals. Middle-skilled occupations comprise clerks, craft and related trades workers, plant and machine operators and assemblers. Low-skilled occupations refer to service and sales workers and elementary occupations.

SO FAR, HIGHLY SKILLED WORKERS HAVE BENEFITTED THE MOST FROM NEW TECHNOLOGIES

As a result of these trends, labour markets are becoming increasingly polarized. Skill-biased technologies that favour high-skilled workers and reduce the demand for middle-skilled workers are a key determinant of this polarization. Thus, on the one hand, automation has led to a direct substitution of jobs and tasks currently performed by workers (in what is often called the displacement effect). On the other hand, increases in productivity (and thus income) for some (mostly high-skilled) workers generate larger demand for goods and services (known as the productivity effect). High-skill-biased technology has increased the demand for low-skilled workers as a second-round effect of its increased demand for high-skill workers. So, while skill-biased technologies have affected the skill composition of the labour market, there is little evidence to suggest that they have reduced the total number of job opportunities significantly (OECD, 2019c).

The hollowing out of middle-skilled occupations has been well documented in the United States and European countries, but the same phenomenon is now spreading to developing countries, except China and Ethiopia. In China, mechanization in the agricultural sector increased the share of routine employment between 2000 and 2010, while in Ethiopia the share of employment in manual occupations increased from around 1995 to around 2012. Some commodity-exporting countries did not experience this polarization since the commodity price boom benefited low-skilled workers (World Bank, 2016b).

One type of skill-biased technology that has contributed to the hollowing out of middle-skilled jobs is routine-biased technology. Together with the off-shoring of tasks from developed to developing countries (which is also partially affected by technological change), new technology has polarized the labour market. Both factors decreased the demand for middle-skilled workers relative to high- and low-skilled workers (Goos and others, 2014).[50] As a result of the emergence of routine-biased technology, middle-skilled workers earned about three quarters of the wages of their college-educated counterparts in 1980; in the United States, middle-skilled workers earned only about half as much as their more educated counterparts. It may not be surprising that the wages of middle-skilled workers declined relative to those of high-skilled workers, since demand for the former group decreased. But the wages of low-skilled workers also declined relative to those of the highly skilled, despite the increased demand for low-skilled workers. In the majority of developed countries, wage disparity as measured by the ratio between wages at the ninth and the first deciles of the wage distribution – called the 90:10 ratio – is higher today than 40 years ago. In the United States, where wage disparity is higher than in other developed countries, the 90:10 ratio rose from 3.66 in 1973 to 5.07 in 2017 (OECD, 2019b).

Earnings inequality and job polarization have also increased in Europe. Bussolo, Torre and Winkler (2018) examine three factors that have affected the distribution of earnings among workers in Germany, Poland and Spain: changes in occupational

[50] It should be noted that a general consensus has not yet formed. Some economists argue that skill-biased technological change does not adequately account for rising wage inequality over the last three decades. See, for example, Schmitt, Shierholz and Mishel (2013).

structure (that is, polarization), returns to education, and labour market characteristics, such as age and gender composition. The study concludes that job polarization can account for a significant share of the observed increases in inequality, while the two other factors played only minor roles in explaining wage inequality. Of particular interest in this analysis is the strong power of occupational structure to explain the increasing 90:10 and 50:10 ratios, more than the increasing returns to education.[51] Most of the displaced middle-skilled workers are likely to move down to jobs categorized as low-skilled, exercising downward pressure on wages for low-skilled workers, explaining the widening wage gaps.

Autor (2019) points out that urban workers who are not college educated have been most adversely affected by routine-biased technology. He also says that job polarization and wage inequalities among different skill or educational groups have been most noticeable in urban areas of the United States since 1980. Urban workers that are not college educated and that enjoy (relatively) high-paying middle-skill jobs in large, high-wage cities have been steadily losing these jobs and shunted into low-wage occupations. These workers now perform substantially less skilled work than decades earlier (Autor, 2019, p. 31). He concludes that technological progress in recent decades has been less beneficial and more disruptive to workers without a college education.

More recently, a debate has emerged on whether wage gaps among workers with a college or higher degree and those with a high-school diploma are decreasing in the United States and some European countries (Valletta, 2016) (see box 2.1). At this moment, it is too soon to tell how this would affect wage distribution at the national level and thus income distribution.

Many attempts have been made to estimate the extent to which jobs could be automated and replaced by machines. As Figure 2.4 shows, all estimates suggest that many jobs are at risk of disappearing due to automation. The share of jobs at risk is especially high in developing countries (the upper part of the figure), where the proportion of manufacturing jobs, including tasks that are intensive in routine skills, is high. Estimates on the impact of automation on developed countries (the lower part of the figure) are wide-ranging, depending on the methodologies applied – for example, occupational versus task-based approaches. Task-based approaches recognize that automation may replace specific tasks instead of entire jobs. Acemoğlu and Restrepo (2018) suggest that what matters for the future labour market is the task content of production methods and the skills acquired by the future labour force. Therefore, estimates using the occupation-based approach to gauge the impact of automation on jobs are likely to be higher. Despite disagreements, most studies and estimates suggest that, in developed countries, middle-skilled jobs that are intensive in routine tasks face a higher risk of disappearing.

[51] The 50:10 ratio refers to the ratio between wages at the fifth and first deciles of the wage distribution.

BOX 2.1

United States of America: higher-education wage premiums flatten

Figure 2.2 shows widening higher-education wage premiums in the United States since 1980. The graph, however, also indicates that the wage premium for college-educated workers rose only marginally between 2000 and 2010. Moreover, from 2010 to 2015, the wage premium for college-educated workers as well as those with post-graduate degrees declined slightly relative to those with a high school diploma or no educational degree.

Valletta (2016) argues that the slow growth of the wage premium – followed by a decline – represents a departure from the long-term trend in widening higher-education wage premiums due to technological changes, as argued in the text.

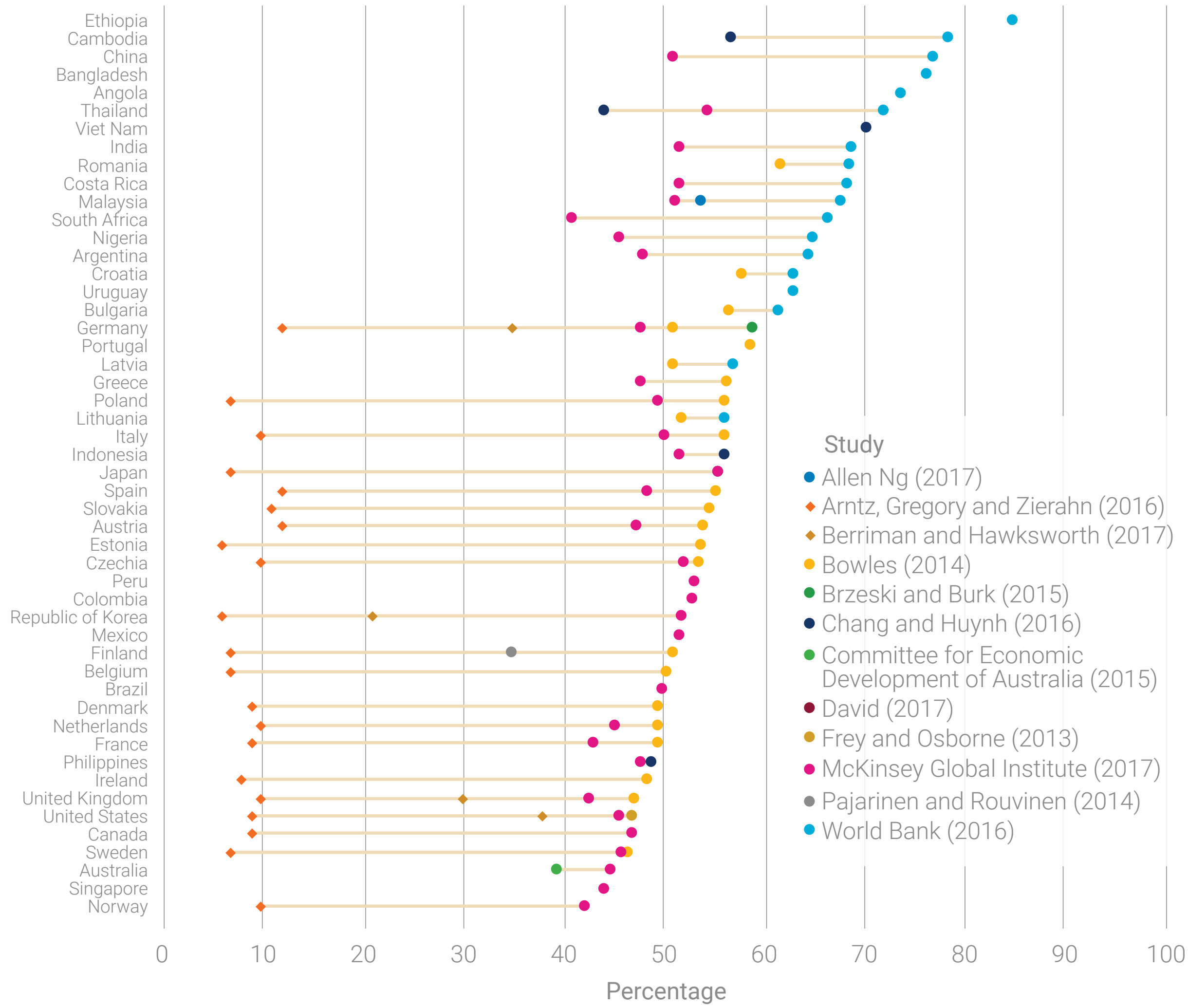
He suggests two reasons for the recent flattening of the wage premium: job polarization and skill downgrading. Job polarization, which contributed to a widening higher-education wage premium, can now account for the flattening of the college wage premium through a shift of college graduates towards jobs that are being displaced by automation and outsourcing. At the same time, increasing demand for non-routine cognitive skills possessed by post-graduate degree holders may contribute to expanding their relative wage advantage against those with a four-year college degree.

Skill downgrading is the process by which weaker demand for cognitive skills "cascades down the skill distribution as highly skilled workers…increasingly compete with and replace low-skilled workers in occupations that rely less heavily on advanced cognitive skills" (Valletta, 2016, p. 3). Weak demand for cognitive skills reflects a maturation of information technology and consequent slowdown in investment in this field (Beaudry and others, 2016).

The higher-education wage premium in 2015 was still larger than in 1980, and higher education is expected to continue to yield positive net returns for many people who complete college or higher education. But the most recent data suggest that the wage premium is likely to show significant variations among individuals with the same educational attainment. Technological progress that encouraged skill upgrading and job polarization is now considered to be a factor in the flattening of the wage premium once progress slows.

It will take some time to see the impacts of wage premium flattening on overall wage and income distributions. Policymakers need to carefully monitor how the slowdown in information technology investment affects wage gaps among workers with different education and skill levels.

FIGURE 2.4
Estimates of the share of jobs at risk of being lost to automation as a result of artificial intelligence and advanced technologies, by study



Source: Calculations based on various studies.
Note: In the key, (T) refers to studies that estimate the effect on jobs using a task methodology. All others rely on a survey that ranks entire jobs at high, middle or low risk of being automated. See Arntz, Gregory and Zierahn (2016) for further explanation.

A few studies examine the direct and more specific impact of robots – the most advanced form of automation – on wages in different education groups. The results are sometimes conflicting and, at other times, draw similar conclusions. A study by Acemoğlu and Restrepo (2017) looks at the impact of robots in the United States. The negative wage effects of robots are found to be stronger on workers with less than a high-school education, with a small (though marginally significant) negative effect on workers with more than a college degree. At the national level, the introduction of robots has been estimated to have a negative effect on the wages of all groups of workers (one more robot per thousand workers reduces wages by 0.25-0.50 per cent), and robots could further widen wage inequality if the educational distribution of workers remains unchanged. Conversely, based on a similar study of six European countries (Finland, France, Germany, Italy, Spain and Sweden), Chiacchio and others (2018) do not find any statistically significant effects of robots on wages in various educational groups.

B. Current technological divides and opportunities for inclusion

The previous section argued that digital technologies in general and automation in particular have been introduced primarily to enhance productive efficiency and, more often than not, showed adverse effects on income and wage inequalities. The evidence reviewed in this section suggests that Governments can shift the impact of technologies from enhancing inequality to enhancing equality, without affecting the speed of technological progress. The keys for success are the declining prices of goods or services that embody new technologies, and the ability of Government to make new technologies more readily accessible and usable by everyone.

MANY OF THE BENEFITS FROM NEW TECHNOLOGIES FOR DEVELOPMENT MAY NOT MATERIALIZE WITHOUT DELIBERATE GOVERNMENT ACTION

The use of new technologies in the public sector is widespread among developed countries, and is increasing in developing countries. For example, Government-issued digital identification (ID) allows a holder to access various public services and government benefits. The system makes it possible to build a digital "Government" in which the provision of public services becomes more efficient, effective and inclusive. In India, advances in mobile technologies have become the foundation for reliable digital networks and sophisticated image recognition technologies that allow ID holders to be readily identified, facilitating their access to various public and financial services. China has demonstrated a significant capacity to develop technological advances in telecommunications, health and education. Healthy China 2030, for example, is an example of how technology is being used to provide health services in remote areas, illustrating how Governments can intervene to encourage a more inclusive use of new technologies.

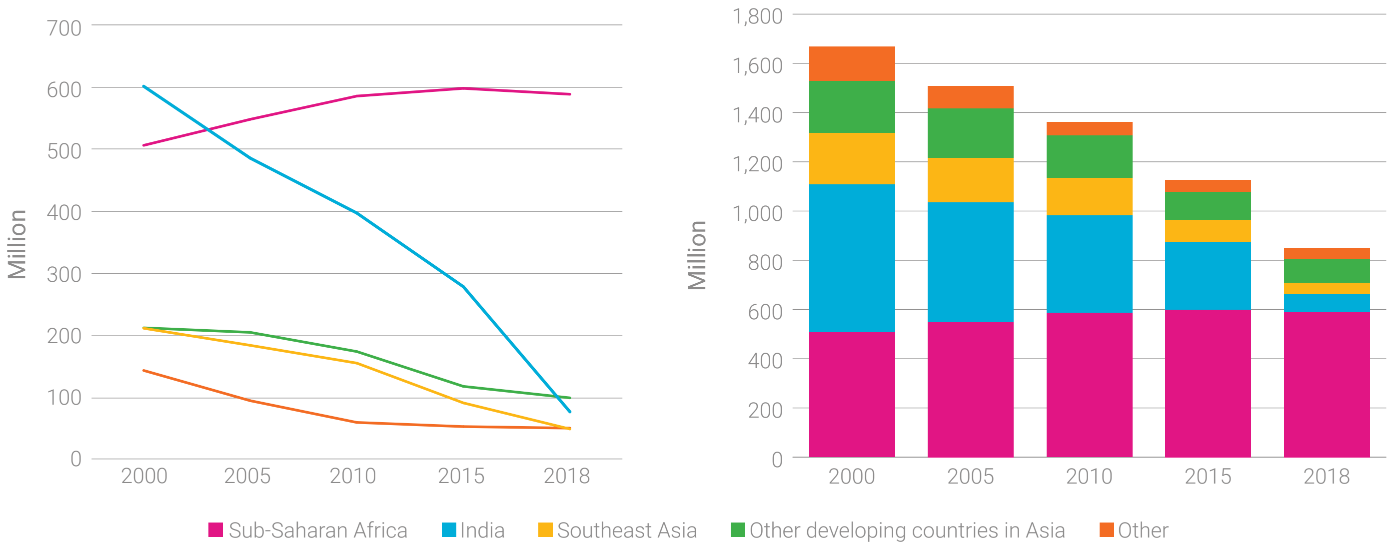
The cases examined below show that, when the right policies are deployed in a coordinated manner, these technologies can drive development and make it possible to create more inclusive societies. Conversely, without an integrated framework of deliberate public policies, the same technologies could make societies more unequal.

LESS THAN 20 PER CENT OF THE POPULATION OF LEAST DEVELOPED COUNTRIES HAVE ACCESS TO THE INTERNET, COMPARED TO OVER 85 PER CENT OF THOSE IN DEVELOPED COUNTRIES

1. Technological divides and unequal access to basic services

The rate of electrification has been accelerating in recent years (see figure 2.5). Still, in 2018, an estimated 850 million people were without this essential service. Within low- and lower-middle-income countries, including the least developed countries, there are typically gaps in access between people living in urban and rural areas, and within urban and rural areas, as discussed in chapter 4. In contrast, most populations living in high-income and upper-middle-income countries have universal access to electricity. A significant disparity is also found in access to the Internet among different income groups (see figure 2.6). Less than 20 per cent of the population of least developed countries have access to the Internet, compared to over 85 per cent of those in developed countries.

FIGURE 2.5
Levels and trends of people worldwide without access to electricity, by selected countries and regions, 2000-2018



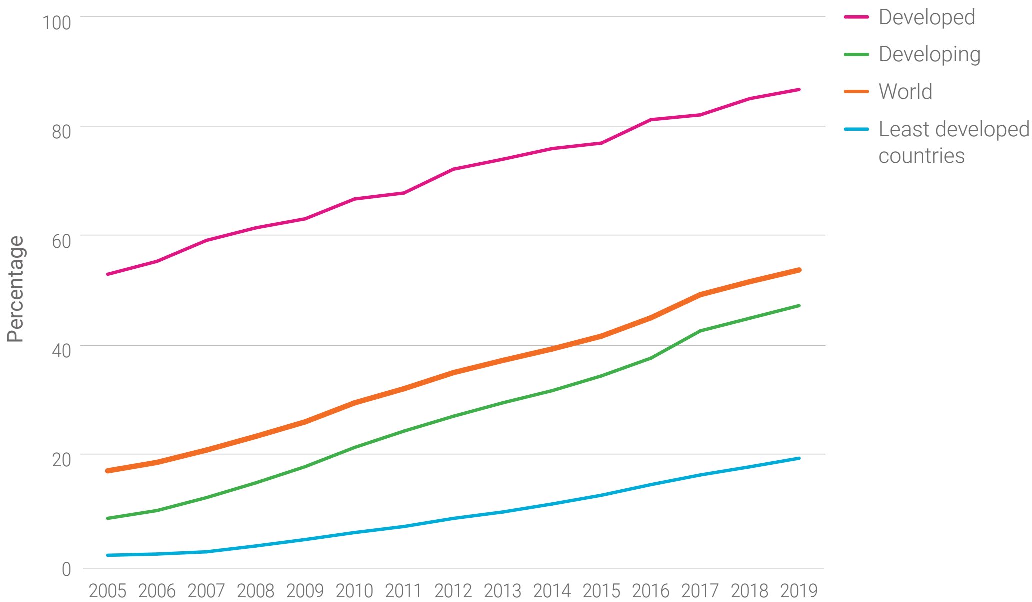
Source: International Energy Agency (2019). *World Energy Outlook 2019*.
Note: The group "Other developing countries in Asia" includes Bangladesh, Democratic People's Republic of Korea, Mongolia, Nepal, Pakistan and Sri Lanka. The group "Other" includes Algeria, Argentina, Bahrain, Bolivia (Plurinational State of), Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Guatemala, Haiti, Honduras, Iran (Islamic Republic of), Iraq, Jamaica, Jordan, Kuwait, Lebanon, Libya, Morocco, Nicaragua, Oman, Panama, Paraguay, Peru, Qatar, Saudi Arabia, Syrian Arab Republic, Trinidad and Tobago, Tunisia, United Arab Emirates, Uruguay, Venezuela (Bolivarian Republic of) and Yemen.

One of the reasons for low Internet coverage is the high annual cost of access. Fixed-broadband Internet in 2016 cost, on average, more than 30 per cent of GNI per capita in least developed countries, but less than 3 per cent in developed countries (ITU, 2017). Among all regions, prices are the highest in Africa. In an extreme case, the annual cost of fixed-broadband Internet access was over 1,700 per cent of GNI per capita in the Central African Republic in 2016, compared to less than 0.8 per cent in the United States.

Price is not the sole reason for the technological divide. Sometimes it reflects existing disparities not only in telecommunications infrastructure, but also educational attainment and general human capital levels among households and regions in a country. A case study in Indonesia (Sujarwoto and Tampubolon, 2016) found that inequality in Internet access was widening among different age, gender, income and education groups, due to the above-mentioned factors.

Technological divides hinder inclusion, since artificial intelligence, machine learning, biotechnology, satellite technologies and their applications in health, education, transportation, agriculture and manufacturing are directly and indirectly affected by the use of the Internet and, in particular, broadband access. Internet divides are likely to prompt schisms in other areas, partly because the Internet is a basic platform for progress in and wider dissemination of several other technologies. For example, Kudasheva and others (2015) show that inequality in access to ICTs is associated

FIGURE 2.6
Percentage of the global population with access to the Internet by country groupings, 2005-2017



Source: International Telecommunication Union (2019). Key ICT indicators for developed and developing countries and the world (totals and penetration rates). Available from www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx. Accessed on 17 December 2019.

with and may have led to higher income inequality in Kazakhstan, where wealthier households can afford higher-quality Internet services while low-income households can afford only lesser quality service with slow, blurry images and unstable streaming. Furthermore, a large gap is found between urban and rural areas in access to broadband in many developing countries. For example, while broadband use in the capital cities of India, Kyrgyzstan and the Republic of Moldova is as high as that in OECD countries, broadband access in rural areas of those three countries is among the lowest in the world (World Bank, n.d.).

2. New technologies and financial inclusion

Lack of access to electricity, mobile phones and the Internet limits the potential benefits of modern conveniences and services that people living in higher-income countries take for granted. Having an account with a financial institution is one such convenience. A bank account provides a person or family with an easy and safe means of saving and helps smooth out personal consumption over time. It can help people accumulate assets and provides financial buffers in case of economic hardship, such as job losses or crop failures. Yet in 2017, about 1.7 billion adults worldwide were without an account at a financial institution. A combination of new and existing technologies, together with appropriate government intervention, can facilitate the use of new technologies by less advantaged people, and reduce disparities in access to financial accounts.

TABLE 2.1
Disparities in financial account ownership by region, education, income and gender, 2011-2017 (percentage)

Country group/year	Account[a]	Account, primary education or less[a]	Account, secondary education or more[a]	Gap by education	Account, income, poorest 40%[a]	Account, income, richest 60%[a]	Gap by income	Account, female[a]	Account, male[a]	Gender gap
Low-income countries										
2011	13	8	23	15	7	17	10	11	16	5
2017	35	29	50	21	26	41	16	30	40	10
Lower-middle-income countries										
2011	29	23	40	17	20	35	15	23	34	11
2017	58	50	66	17	51	63	12	53	63	10
Upper-middle-income countries										
2011	57	51	65	13	42	67	25	23	4	23
2017	73	66	80	15	62	80	18	19	14	19
High-income countries										
2011	88	71	92	20	85	91	6	86	90	4
2017	94	84	95	11	90	96	6	93	95	2

Source: Based on Demirgüç-Kunt and others (2018).
Note:
a. Among persons 15 and older.

Table 2.1 shows shares of account ownership at financial institutions, such as banks, microfinance lenders and other types of regulated institutions in the global adult population and disparities based on education, income and gender. The table shows that high-income countries achieved near universal ownership of financial accounts in 2017. In these countries, the income and gender gaps were small, and educational disparities, while larger, shrank over time.

In low- and middle-income countries, the shares of financial account ownership in the total adult population are lower and disparities higher compared to high-income countries. However, the shares of account ownership have increased consistently over time in all country groupings and in all categories. Increased access to electricity and digital technologies is thought to have contributed to this positive trend (Demirgüç-Kunt and others 2018). Mobile money services, through which users can store and transfer funds through wireless transmissions, has been one contributing factor. Some 350 million adults worldwide opened their first financial account between 2014 and 2017.[52] As of 2017, 9 per cent of adults, or 13 per cent of account owners, had opened their first financial account for the purpose of receiving private sector wages, government payments or proceeds from the sale of agricultural products (ibid.).

The widespread use of mobile phones and the Internet has been a major contributor to greater financial inclusion. At the same time, digital technologies have encouraged the

[52] Calculation based on data from the Global Findex Database 2017 (https://globalfindex.worldbank.org/) and the *World Population Prospects 2019* (https://population.un.org/wpp/).

emergence of new entrepreneurs and financial technologies. Mobile networks provide an incentive for private companies to enter the electricity market, even in rural areas, where cost recovery on investments and the illegal use of electricity have traditionally been problematic. The networks allow users of decentralized systems to remotely pay bills via smartphones. Using the same networks, the electricity producer can collect usage data, disable a device if the customer misses a payment, and turn the device back on when the payment is made. In fact, providers of mini- and off-grid electricity systems have entered the market in many parts of Africa where mobile networks are available (IEA, 2017).[53]

Despite overall increases in financial account ownership, disparities among groups within countries are pervasive. Overall, gender gaps as well as income and educational disparities did not diminish between 2011 and 2017 despite the widespread use of mobile phones and the Internet.

The experience of India suggests that mobile digital technologies need to be complemented by other technologies to reduce inequality in access to financial services (see box 2.2).

India managed to achieve more equal access to financial accounts by complementing mobile technologies with a national system of digital IDs and an affordable electricity system that provides an uninterrupted supply of stable current. At present, many developing countries have digital ID systems (McKinsey Global Institute, 2019), and some countries are on track to achieve universal access to modern energy during the 2020s (IEA, 2018). The experience of India is likely to be replicated in other countries in the near future.[54]

3. New technologies in other sectors

New technologies have been introduced in other areas as well. For example, mobile technologies can provide small-scale farmers with better access to critical information about markets for their products, help them obtain fair prices, and improve production planning and commercialization.[55] Unmanned aerial vehicles ("drones"), which rely on the global positioning system or are remotely controlled, also have potential for increasing the productivity of farmers in less technologically advanced areas by providing up-to-date information. Teaching and learning processes have improved in schools that have integrated ICTs into their curricula compared to schools that have not (Sangrà and González-Sanmamed, 2010), and open online courses can also become a major equalizer in terms of universal access to education. The United Nations (2019b) has examined actual and potential applications of new technologies in the areas of the agriculture, education, health and housing.

[53] The most popular combination of mobile payments and decentralized systems is the pay-as-you-go system, which uses a solar-powered module with a battery and small appliances. See Runyon (2016) and Wogan (2013).

[54] China is another country that has managed to increase its share of adults with bank accounts. The share in 2017 stood at 80 per cent, compared to 64 per cent in 2011. The share of adults with an account among rural dwellers jumped from 58 per cent in 2011 to 77 per cent in 2014 (Demirgüç-Kunt and others, 2018).

[55] In fact, the World Bank (2009) found that "with 10 per cent increase in high-speed Internet connections, economic growth [in agriculture] increases by 1-3 per cent." Chavula (2014) shows that the use of the Internet and mobile phones has played a significant role in enhancing the agricultural production of small farmers more than large farmers in 34 countries in Africa. The study warns, however, that higher education levels and skills are required for more effective adoption and utilization of new technologies.

BOX 2.2

India: Harnessing the potential of digital technologies for more inclusive development

India has successfully managed to use digital technologies to reduce disparities among population groups. A combination of new public infrastructure and government action was behind the success of a new identification system that is increasing ownership of financial accounts and making public services more effective.

The Unique Identification Authority of India was set up in 2008 and introduced demographic and biometric identification cards (using fingerprints and iris scans) with unique ID numbers, known as the *Aadhaar* ("foundation" or "base" in the Hindi language). The numbers can be used to open financial accounts at banks or other businesses.[56] In 2014, the Government of India instructed banks to provide accounts to people without them, using their *Aadhaar* numbers or other sources of information about their identities and addresses. The number of people without bank accounts declined by more than half, from 557 million in 2011 to 233 million in 2015. By 2017, 80 per cent of adult Indians had at least one bank account, which is significantly higher than the average share in developing countries (63 per cent). The biometric ID helped reduce gender-, income- and education-based gaps in access. In fact, the system has also been used to enhance the effectiveness of social protection, health and voting programmes.

Before the introduction of *Aadhaar* numbers, those who were less advantaged were unlikely to have an official registered ID, which was necessary to open an account.[57] Improvements in electricity access have facilitated the opening of financial accounts and their use. Electrification has reached 82 per cent of the country's population, and the International Energy Agency predicts that India will achieve universal access in the early 2020s.

Despite this success, 48 per cent of bank accounts in India were reported as inactive in 2018 (Demirgüç-Kunt and others, 2018). This suggests that the government programme to promote account ownership, launched in 2014, is still in its infancy. However, more accounts are expected to become active as a greater number of people acquire mobile phones.Two thirds of inactive account holders now have mobile phones, and this share is increasing.

Among these sectors, advances in medical technologies are most notable. Recent scientific breakthroughs in biology and genetics and applications of robotics and artificial intelligence to medical treatments and diagnostics have possibilities we have yet to imagine. At the same time, these advances are likely to benefit the rich more than people in poverty, thus widening health inequalities among different socioeconomic groups.[58] That said, new technologies have the potential

[56] See https://uidai.gov.in, the official site of the Unique Identification Authority of India.

[57] There is a controversy surrounding the *Aadhaar* with regard to the privacy or, more generally, dual use of technologies, which is beyond the scope of this report. For details, see Bhabha and Bhatia (2016) and McKinsey Global Institute (2019).

[58] For medical innovations and their impacts on health inequality, see Weiss and others (2018), Chang and Lauderdale (2009) and Goldmann and Lakdawalla (2005).

to significantly improve the health status of humanity and to reduce socioeconomic inequalities in health. Two groups of technologies are considered here – mobile health (mHealth) technologies and the Internet.

The practice of medicine and public health supported by mobile devices is known as mHealth. Its applications improve health-care delivery and monitoring systems, which can enhance the quality of life for underserved populations and reduce inequalities in access to high-quality and affordable health care. The technologies can be used to respond promptly and effectively to both communicable and non-communicable diseases. Currently, the most common uses of mHealth are text-messaging and cell reminders to follow up on appointments and health behaviours, which have reduced the treatment time of diseases, no-show appointment rates and phone call costs (Beloev, 2016).

Reaching all population groups with the positive benefits of health technologies will take time. Policymakers can accelerate this process, thereby reducing inequalities, by facilitating access to and adoption of relevant technologies. Applications of mHealth include the direct provision of care via mobile telemedicine as well as the training of and collaboration with health workers. These applications have the potential to remove physical barriers to wider and better care and service delivery to people in poverty by increasing their access to care, strengthening health systems management, and enhancing the reliability of supply systems and communication. They can also help overcome infrastructure and hospital resource constraints by reaching people residing in remote areas and reducing the impact of an inadequate number of health-care workers – whose services are often difficult to retain in rural areas. Expansion of telemedicine's infrastructure throughout health systems is needed, particularly in rural areas, in order to overcome health staff shortages (Nouhi and others, 2012).

The Internet is fundamental to the use of ICTs in health care (known as eHealth). The Internet enables medical information to be communicated more broadly and promptly, facilitating the sharing of best practices, and helps doctors in the diagnosis of diseases and injuries. Similarly, web-based learning offers continuing education to health-care workers, tailored to their needs, skill levels and availability. The use of web-based data entry and storage means that large databases are available online, which can foster wider and more effective disease surveillance. For example, access to disease reports by health officials can help to ensure timely identification and control of outbreaks as well as efficient long-term surveillance of endemic conditions (Nouhi and others, 2012).

Access to health technologies can make health-care provision more inclusive. However, this will not necessarily lead to a reduction in digital inequalities without differentiated policies on technology adoption. Neter and Brainin (2012) show that the Internet can, in fact, increase inequalities since a clear association has been found between eHealth literacy and different social background attributes.

C. Policy considerations

Technological change is driving wage and income inequality upwards. Even well-intended policies to bring the advantages of technology to everyone have often benefited most those groups that are already better off. Those with the most resources, be they human or financial, are best positioned to take advantage of the development of innovative technologies. So, not surprisingly, technological change has greatly favoured highly skilled workers.

The fourth industrial revolution has improved productivity in large segments of the economy, but wages have not grown in tandem. In addition, job polarization triggered by technological change has contributed to the rise of wage inequality in many parts of the world.

THE ADVERSE CONSEQUENCES OF RECENT TECHNOLOGICAL PROGRESS ARE NOT INEVITABLE

These adverse consequences of recent technological progress are not inevitable, however. As illustrated in this chapter, proactive policies and supportive institutions can help ensure that technological dividends are widely shared. While doing so may require a broad range of strategies, three key policy interventions are fundamental:

Building forward-looking and inclusive education systems. Rapid technological progress requires a continual upgrading of workforce skills. Once-and-for-all education at a young age is no longer sufficient. It is therefore important to invest in skills and knowledge that enable workers to perform new tasks over a lifetime of changing work environments, making sure that education systems are inclusive so that opportunities are equitably shared.

Supporting people through life and work transitions. This includes expanding social protection systems and tailoring them to the fourth industrial revolution. In general, existing social protection systems have failed to properly address the consequences of rapid technological progress on workers and households. Such systems will have to cover, for instance, a growing number of people under non-standard working arrangements, as chapter 6 describes.

Strengthening efforts to bridge the technological divide within and among countries, including by investing in infrastructure. To harness technological progress for a more equal world, it is critically important that access to new technologies is universal and that all know how to use them. An enabling infrastructure requires investment in connectivity, especially in historically marginalized communities.

In the labour market, new technologies are taking over jobs and tasks currently performed by workers. However, technological change also creates the need for new jobs and tasks, including those that are necessary to use, test, supervise and market new products and services. Differences are found across both companies and countries in the extent to which jobs are either being cut or redesigned based on changing requirements. Strong, forward-looking education systems and adequate support can enable countries to train workers and align their workflows in response to automation.

Strengthened redistribution is needed to counterbalance widening inequality. At the same time, as more workers become more highly skilled, and as the share of medium-skilled workers consolidates and the relative size of the low-skilled workforce declines, the need for redistribution will diminish.

Not only are highly skilled workers benefiting the most from new technologies in many countries, but productivity gains brought about by such technologies are being captured by a small number of dominant companies. The presence of monopolistic or oligopolistic companies have distorted market competition and hindered the diffusion of new technologies within and among countries. Anti-trust policies may need to be adjusted to prevent first-movers from establishing dominance and to maintain fair competition in the digital economy.

Considerable policy intervention is needed at national, regional and global levels to make sure that technologies do not widen existing divides within and among countries and leave marginalized groups and many developing countries behind. Many of the less technologically advanced countries, including the least developed countries, will need international support for their national policy efforts in strengthening innovation capacities, including facilitation of technology transfer, access, adoption and development. At the global level, it is important for the international community to agree on a more flexible approach to intellectual property rights that can provide adequate patent protection, while also enabling and facilitating access to technological enhancements within and among countries.

IN ORDER TO HARNESS THE POTENTIAL OF NEW TECHNOLOGIES, GOVERNMENTS NEED TO INTRODUCE POLICIES AND STRATEGIES TO MAKE THEM ACCESSIBLE TO ALL

Governments need creative solutions to ensure that the benefits of new technologies are broadly shared. The direction of technological change partly depends on policy, including tax incentives and public investment in research and development. Policies for research and development can promote innovation that prioritizes technologies that create new jobs or complement – rather than displace – existing jobs. Another solution is to deploy funds to acquire stakes in technological innovation and commercialization so that the profits they generate can be shared with the wider public rather than mainly benefiting a narrow group of stakeholders.

Finally, ensuring that the equality-enhancing opportunities outpace the risks involved in technological change requires integrated, far-sighted and government-wide strategies. These must be complemented by policies that enable access to basic social services, infrastructure, employment and financial inclusion. To be effective, supportive policies that enable technology transfer, adoption and development in productive activities in the agriculture, manufacturing and service sectors have to be carried out in tandem with wider access to education, basic services (water, sanitation and electricity), employment and financial inclusion.