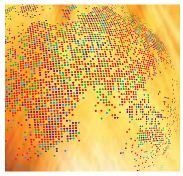
6.



Technology's potential for divergence and convergence: Facing a century of structural transformation

Will the technological transformations unfolding before our eyes increase inequality? Many think so, but the choice is ours. There certainly is historical precedent for technological revolutions to carve deep and persistent inequalities. The Industrial Revolution may have set humanity on a path towards unprecedented improvements in well-being. But it also opened the Great Divergence,[1] separating societies that industrialized,[2] producing and exporting manufacturing goods, from many that depended on primary commodities well into the middle of the 20th century.[3] And by shifting the sources of energy towards the intensive use of fossil fuels (starting with coal), the Industrial Revolution launched production pathways culminating in the climate crisis (chapter 5).[4]

Whether the ongoing changes in technology can be characterized as a revolution is for future historians to determine. The digitalization of information and the ability to share information and communicate instantaneously and globally have been building over several decades, as with computers, mobile phones and the internet. The 2001 Human Development Report considered how to make these and other new technologies work for human development, focusing on their potential to benefit developing countries and poor people.[5] While the report did not address technology's impact on jobs and earnings in detail, it highlighted the growing demand for technology skills and the potential for job creation in both developed and developing economies, suggesting the possibility for reducing inequality within and across countries. But recent advances in technologies such as automation and artificial intelligence, as well as developments in labour markets over the course of the 21st century, show that these technologies are replacing tasks performed by humans—raising with heightened urgency the question of whether technology will give rise to a New Great Divergence.

Advances in artificial intelligence grabbed headlines when a computer programme became, in just a few hours, the world's best chess player. The programme had no prior information on how to play the game. Given only the rules, it taught itself how to win—not only at chess but also at Go and Shogi.[6] This was the latest of several technological breakthroughs powered by artificial intelligence techniques known as machine learning—particularly deep learning—which enables machines to match, or even surpass, what humans can do on tasks ranging from translating languages to recognizing images and speech.[7] As artificial intelligence continues to improve the benchmark performance in a wider range of tasks,[8] it is likely to reshape the world of work in fundamental ways—for workers performing those tasks and across the entire labour market.[9]

Artificial intelligence is not the only relevant technology. Nor does it work in isolation. It interacts with digital technologies in ways that are reshaping knowledge-based labour markets, economies and societies.[10] Perhaps for the first time in human history, these technologies are known almost everywhere. East Asian countries are investing heavily in artificial intelligence and in advances in its use (discussed later in the chapter). And African countries have seized the potential of mobile phones to foster financial inclusion.[11]

These technologies also change politics, culture and lifestyles. Basic artificial intelligence algorithms meant to increase the number of clicks in social media have led millions towards hardened extreme views.[12] In some countries family and friends are being displaced by the internet as the main vehicle for couples to meet, partly because of better artificial intelligence algorithms for matching people.[13] The world of finance is being fundamentally reshaped, with nonfinancial technology firms providing payment services. China leads the way in mobile payments, which represent 16 percent of GDP, followed by the United States, India and Brazil—but at a distance, at still less than 1 percent of GDP.[14] These firms are also extending credit and other financial services. In China artificial intelligence enables online lenders to make decisions on loans in seconds, with new credit granted to more than 100 million people.[15] And central banks from China[16] to Rwanda[17] are considering digital currencies.

Now take a step back. Technology has always progressed in every society, creating disruptions and opportunities (from gunpowder to the printing press). But the advances were typically one-off and did not translate into the sustained and rapid progress[18] that Simon Kuznets described as "modern economic growth."[19] Sustained improvements in productivity and living standards depend on constantly introducing new ideas and using them productively.[20] But having these gains in productivity and well-being reach everyone is not a given, and people who lack access can face new and deeper deprivations when access is simply assumed.[21]

Technology is not something outside economies and societies that determines outcomes on its own.[22] It co-evolves with social, political and economic systems. This implies that it takes time for the productive use of technology to settle, because it requires complementary changes in economic and social systems.[23] But how technology will shape the evolution and distribution of human development in the 21st century does not need to be left to chance. At a minimum another Great Divergence should be avoided while simultaneously addressing the climate crisis.

Technology is not something outside economies and societies that determines outcomes on its own

The impact of technical change can be an explicit concern for policymakers.[24] With a clear emphasis on enhancing human development, it can increase the employability of workers and improve the reach and quality of social services. Investments in artificial intelligence need not simply automate tasks performed by humans; they can also generate demand for labour. For example, artificial intelligence can define more detailed and individualized teaching needs and thus generate more demand for teachers to provide a wider range of education services.[25] More generally, technological change can be directed to both reduce inequality and promote environmental sustainability.[26]

Can artificial intelligence enhance human development? The direction of technological change involves many decisions by governments, firms and consumers.[27] But making technology work for people and nature is already part of the conversation in some countries.[28] Public policy and public investment will drive technological change, as they have historically.[29] But so will the distribution of capabilities. The cleavages that may open are not necessarily between developed and developing countries or between people at the top and people at the bottom of the income distribution. North America and East Asia, for instance, are far ahead in expanding access to broadband internet, accumulating data and developing artificial intelligence.[30]

This chapter shows that while access to basic technologies is converging, there is a growing divergence in the use of advanced ones, echoing the findings in part I of the Report. The chapter describes how some aspects of technology are associated with the rise of some forms of inequality—for instance, by shifting income towards capital and away from labour and the increasing market concentration and power of firms. It then examines the potential for artificial intelligence and frontier technologies to narrow inequalities in health, education and governance—pointing to technology's potential in redressing inequalities in human development. It concludes that technology can either replace or reinstate labour—it is ultimately a matter of choice, a choice not determined by technology alone.

Inequality dynamics in access to technology: Convergence in basic, divergence in enhanced

A refrain throughout this Report is that despite convergence in basic capabilities, gaps remain large in enhanced capabilities—and are often widening. This is also the case for technology, especially for access, the focus here. To be sure, this is only a partial perspective, given the inequalities in leveraging new technologies, having a seat at the table in the development of these technologies and being trained or reskilled for working with them. There are also gender disparities, with women and girls under-represented in education and careers in science, technology, engineering and mathematics.[31] Still, the evidence on access in this chapter shows that despite convergence in access to basic technologies (which is still far from equal), there is divergence in the access to and use of advanced ones.

In fact, the ability to access and use digital technologies has a defining role both in the pattern of production and consumption and in how societies, communities and even households are organized. More and more depends—to a great extent—on the ability to connect to digital networks. This section shows that:

- Groups with lower human development have systematically less access to a wide range of technologies, as is widely established.
- Gaps in basic entry-level technologies, though still evident, are closing—reflecting convergence in basic capabilities.
- Gaps in advanced technologies[32] (even when considered commonplace by the standards of many) are widening—mirroring the pattern in enhanced capabilities identified earlier in the Report.

Inequalities in access to technology are widespread

The higher the level of human development, the greater the access to technology (figure 6.1, top panel). The digital revolution has moved fast and had enormous impact, but it is far from universal. In 2017 almost 2 billion people still did not use a mobile phone.[33] And of the 5 billion mobile subscribers in the world, nearly 2 billion—most of them in low- and middle-income countries—do not have access to the internet.[34] In 2017 the number of fixed broadband subscriptions per 100 inhabitants was only 13.3 globally and 9.7 in developing countries, and the number of mobile broadband subscriptions per 100 inhabitants was 103.6 in developed countries compared with only 53.6 in developing countries.[35] Inequalities are much greater for advanced technologies, such as access to a computer, internet or broadband (figure 6.1, bottom panel).

The convergence in basic technologies, such as mobile phones,[36] has empowered traditionally marginalized and excluded people—with greater financial inclusion a good illustration (box 6.1). But digital gaps can also become barriers not only in accessing services or enabling economic transactions but also in being part of a "learning society."[37] It is thus important to complement this static picture of gaps with an analysis of how they are evolving.

Catching up in the basics, widening gaps in advanced technologies

Inequalities in access to basic entry-level technologies are shrinking. Mobile phones, including basic service, have spread rapidly in most parts of the world (figure 6.2, left panel). In 2007 there were 102 mobile subscriptions per 100 inhabitants in developed countries compared with 39 in developing countries. By 2017 the gap had narrowed, with 127 mobile subscriptions per 100 inhabitants in developed countries and 99 in developing countries. This convergence reflects both rapid expansion at the bottom and a binding constraint at the top, with little room for further growth.

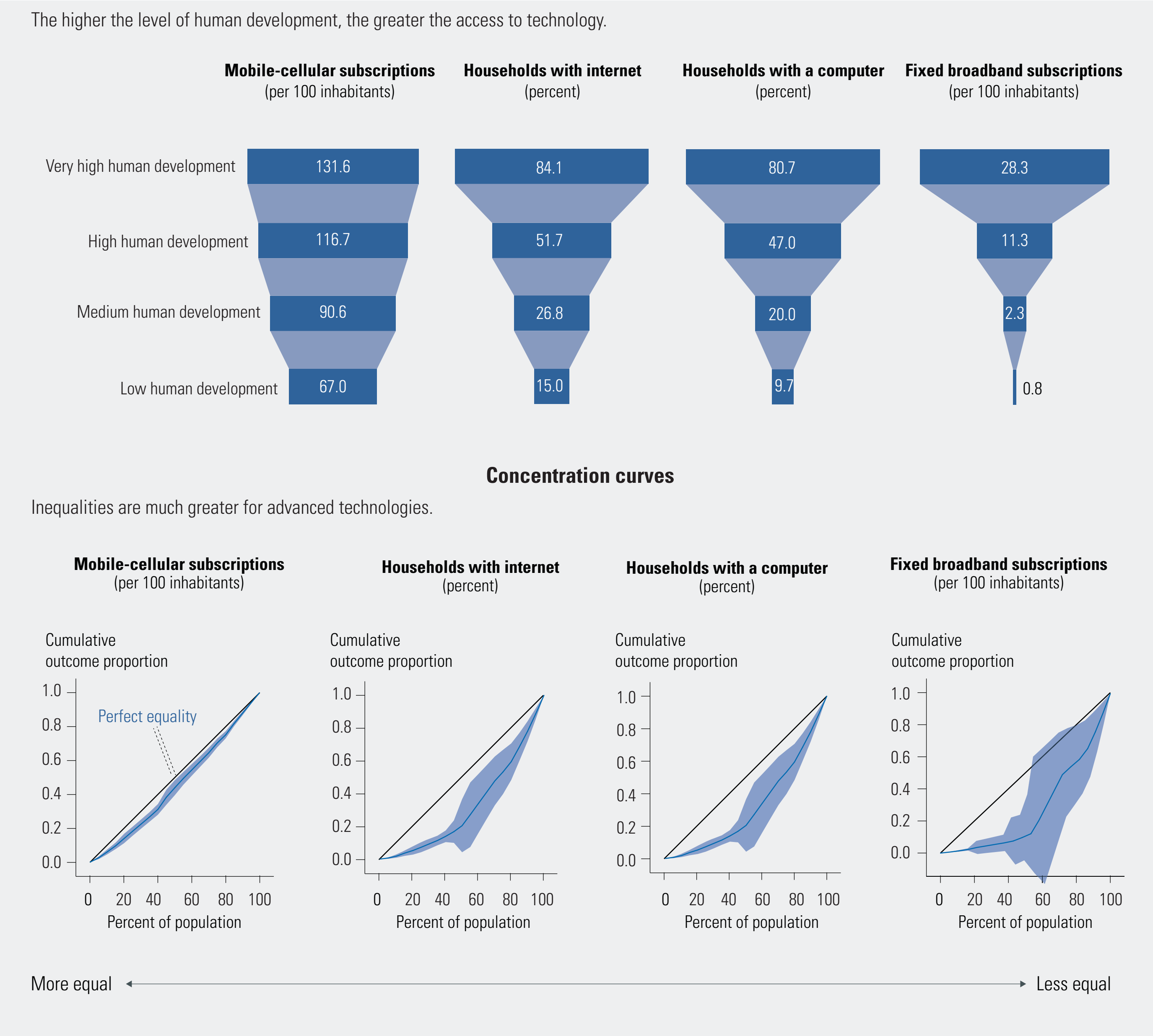
In more empowering areas of technology, involving access to more information and a potential transition from consuming content to producing it, the gaps are larger and widening (figure 6.2, right panel). Low human development countries have made the least progress in these technologies—a trend consistent with the widening gaps in installed broadband capacity, especially in absolute differences, to which the chapter turns next in some detail.[38]

In more empowering areas of technology, involving access to more information and a potential transition from consuming content to producing it, the gaps are larger and widening

The distinction between the number of telecommunication subscriptions and the availability of bandwidth mattered little when there was only fixed-line telephony, since all the connections had essentially the same bandwidth. But as artificial intelligence and related technologies continue to evolve, bandwidth will be increasingly important (as will be cloud computing, which depends on the ability to connect computers with each other). Access to bandwidth, comparable in quantity and quality to that in developed countries, is essential for developing countries to cultivate their own artificial intelligence and related applications. Also essential are transferring and adopting technologies developed by leaders in the digital world. Taking these two groups of countries in the aggregate, there has been convergence. In 2007 high-income countries had 22.4 times

FIGURE 6.1

Digital divides: Groups with higher development have greater access, and inequalities are greater for advanced technologies, 2017



Note: Data are simple averages across human development groups. Shaded areas are 95 percent confidence intervals.
Source: Human Development Report Office calculations based on country-level data from the International Telecommunications Union.

the bandwidth per capita of other countries; by 2017 the ratio had fallen to 3.4 (figure 6.3).

While the convergence in broadband among developing countries as a whole is positive, the pattern of convergence in technologies has differed across regions. Take mobile subscriptions and installed broadband potential. The regional distribution of mobile subscriptions already reflects the population distribution (meaning that the distribution of both is roughly equivalent), and in East Asia and the Pacific mobile subscriptions have already caught up with the region's share in the global population (figure 6.4). In Africa there is still a difference, though convergence is not far off. But the distribution of installed bandwidth potential follows neither

BOX 6.1

Mobile technology promotes financial inclusion

Financial inclusion is the ability to access and use a range of appropriate and responsibly provided financial services in a well regulated environment.[1] Mobile money, digital identification and e-commerce have given many more people the ability to save money and transact business securely without needing cash, to insure against risks and to borrow to grow their businesses and reach new markets.

In 2017, 69 percent of adults had an account with a financial institution, up 7 percentage points from 2014.[2] That means more than half a billion adults gained access to financial tools in three years.

Well known examples of mobile money—platforms that allow users to send, receive and store money using a mobile phone—include Kenya's M-Pesa and China's Alipay. Mobile money has brought financial services to people long ignored by traditional banks. It reaches remote regions without physical bank branches. It can also help women access financial services—an important aspect of equality, since women in many countries are less likely than men to have a bank account.[3]

Increases in e-commerce have also been dramatic, including individuals and small businesses selling products and services on online platforms. In particular, inclusive e-commerce, which promotes the participation of small firms in the digital economy, is important because it can create new opportunities for traditionally excluded groups. In China, for example, an estimated 10 million small and medium enterprises sell on the Taobao platform; nearly half the entrepreneurs on the platform are women, and more than 160,000 are people with disabilities.[4]

From artificial intelligence to cryptography, innovation in financial technology is transforming the financial sector globally.[5] While financial technology offers many potential benefits, there are also considerable concerns about these new technologies' vulnerabilities. Blockchain technology, for one, provides applications that include a secure digital infrastructure to verify identity, facilitate faster and cheaper cross-border payments and protect property rights. But these technologies bring new risks that are not fully considered by existing regulations.[6] Policymakers will need to address several tradeoffs to reap financial technology's potential benefits.

Notes

1. UNCDF 2019. 2. Demirgüç-Kunt and others 2018. 3. McKinsey 2018; World Bank 2016. 4. Luohan Academy 2019. 5. He and others 2017. 6. Sy and others 2019.

the distribution of the population nor the distribution of gross national income. East Asia and the Pacific has already taken the lead in installed bandwidth potential, with 52 percent in 2017.

So, the emerging technology cleavages do not follow a simple developed–developing country dichotomy, and the emerging disparities are fairly recent. From 1987 to 2007 little changed in the global ranking of installed bandwidth potential (figure 6.5). In 1987 a group of developed countries were in the top global ranks: The United States, Japan, France and Germany hosted more than half the global bandwidth, mainly through fixed-line telephony. At the turn of the millennium things started to change, notably with the expansion of bandwidth in East and North Asia: By 2007 Japan, the Republic of Korea and China occupied ranks 1, 3 and 5. And in 2011 China took the lead in installed bandwidth. Beyond broadband, projections on the distribution of future economic benefits linked to artificial intelligence confirm this shifting geography of technology divergence, with estimates suggesting that by 2030 about 70 percent of the global economic benefits tied to artificial intelligence will accrue to North America and East Asia.[39]

New technologies tend to have higher prices when initially introduced, with prices falling and quality increasing as the technologies diffuse.[40] Thus, every innovation has the potential to initially carve a divide, at the beginning of the diffusion process—a point also made in chapter 2, in the discussion of how gradients in health emerged when health technologies became available. The contribution here is to show that the gaps for advanced technologies are widening, not closing—in a new geography of divergence that goes beyond developed and developing countries. Avoiding a New Great Divergence implies paying attention to the evolution of technology distribution, because benevolent technology diffusion is neither automatic nor instantaneous.[41] Instead, technology may well catalyse divergence in human development outcomes. By what processes? That is the topic of the next section.

East Asia and the Pacific has already taken the lead in installed bandwidth potential, with 52 percent in 2017

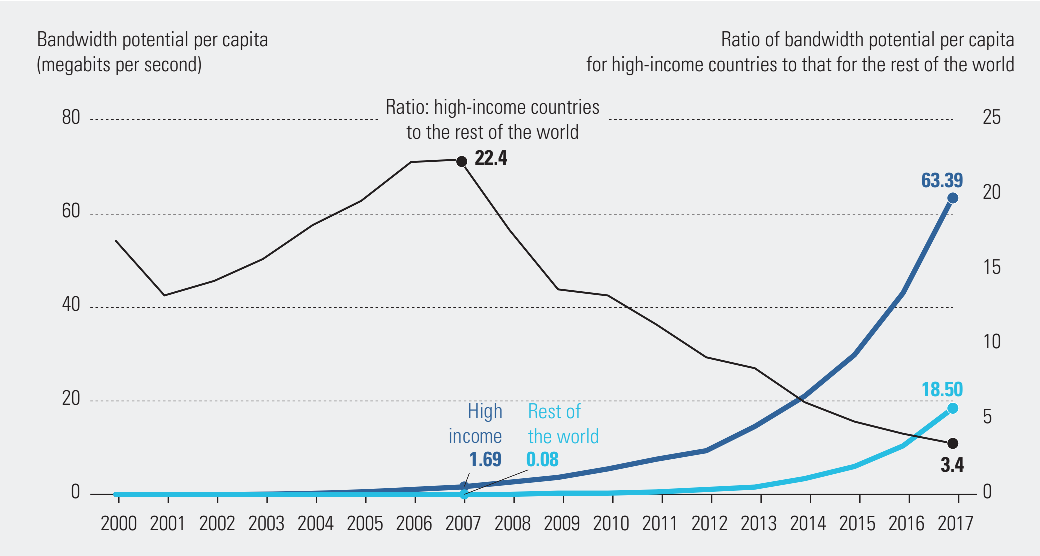
FIGURE 6.2

Dynamics of access to technology

Note: Convergence and divergence are tested for in two ways: by using the slope of an equation that regresses the change over 2007–2017 with respect to the initial value in 2007 (with ordinary least squares, robust and median quantile regressions) and by comparing the gains of very high human development countries and the gains of low and medium human development countries. For mobile subscriptions there is convergence according to both metrics (*p*-values below 1 percent). For fixed broadband subscriptions there is divergence according to both metrics (*p*-values below 1 percent).
Source: Human Development Report Office calculations based on data from the International Telecommunication Union.

FIGURE 6.3

The bandwidth gap between high-income and other countries fell from 22-fold to 3-fold



Source: Hilbert 2019.

Technology is reshaping the world: How will it shape inequality in human development?

Technology is reshaping lives—not only economies but also societies and even politics. What specific changes will bear on inequality in human development? This question is difficult to address, in part because it may never be possible to assign to technology alone any of the major changes that will reshape inequality in human development, especially with globalization and its interaction with technological change also playing a major role. Still, this section highlights some emblematic ways in which technology is upending previously stable patterns in the distribution of income and economic power. The aim is not so much to attribute causality as to give a sense of technology's potential to reshape inequalities in human development over the next few years.

Unravelling stable trends[42]

For most of the 20th century the shares of national income going to labour and to capital held remarkably constant across many economies.[43] This was far from a foregone conclusion to those witnessing the evolution of economic growth.[44] And it may have been the result of creating and strengthening such institutions as trade unions and social insurance.[45] However, with a decline in labour's share of income since the 1980s across both developed and developing economies, this empirical regularity has been unravelling.[46] For developed economies, technology has been a key driver of the decline, in part by replacing routine tasks, as described in chapter 2.[47] For developing countries the evidence is ambiguous, with both technology and globalization playing important roles.[48]

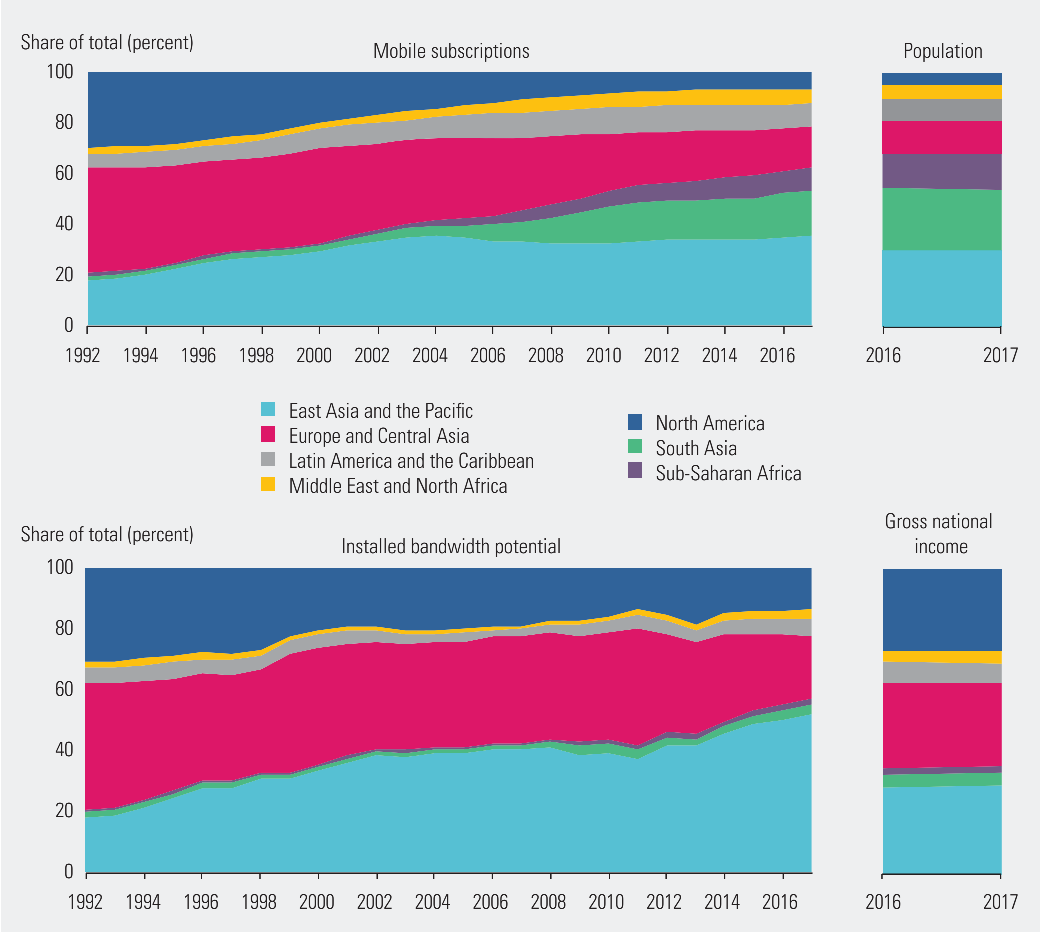
A related trend is the steep decline in the price of machinery and equipment, such as computers (generally designated as capital or investment goods), relative to the price of consumer goods.[49] Since 1970 the relative prices of investment goods in developing countries fell by almost 60 percent, with 75 percent of the decline occurring from 1990 onwards.[50] Among investment goods the price decline has been dramatic for computing and communications equipment, pointing to a link between technology and the incentives for firms to replace labour with capital, a process that in developing countries was also associated with greater integration in global value chains.[51]

Another recent development—linked to the two trends just noted as well as to the increase in

For most of the 20th century the shares of national income going to labour and to capital held remarkably constant across many economies

FIGURE 6.4

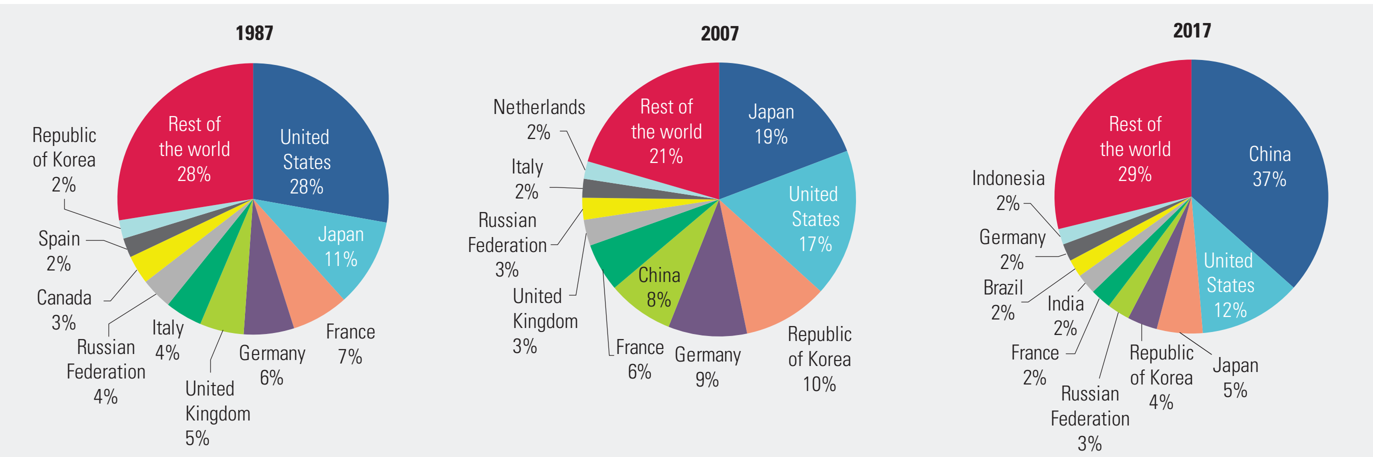
The distribution of mobile subscriptions is converging to the distribution of population by region, but installed bandwidth potential is not



Source: Hilbert 2019.

FIGURE 6.5

From 1987 to 2007 little changed in the global ranking of installed bandwidth potential, but at the turn of the millennium things started to change, with the expansion of bandwidth in East and North Asia



Source: Hilbert 2019.

corporate profits (discussed below) and changes in corporate income tax rates (discussed in chapter 7)—is the shift in the balance of savings held by households and by firms. National savings (comprising household, corporate and government savings) are needed to fund investments. Until the late 1980s most savings were held by households, but today as much as two-thirds are accounted for by the corporate sector.[52] And given that corporate investment has been stable, this means that corporations have been holding on to these savings, in some countries using them to repurchase their own stock.

Perhaps more consequential for the distribution of income is a breakdown in many countries in the association between improvements in labour productivity and the typical worker's earnings, well documented for developed countries. This Report has already shown the trend towards the accumulation of income at the top in several countries (chapter 3). Here the emphasis is specifically on labour income. This breakdown between productivity and earnings not only goes against what used to be stable trends but is also inconsistent with simple models of the labour market.

As workers become more productive (in part as a result of technological change), one would expect their earnings to increase. That is, after all, the assumed process for technological change to deliver improvements in living standards—perhaps not to everyone immediately but for the majority over time. And indeed, until the 1980s real average earnings for the bottom 90 percent of the population (a proxy for the income of a typical household) increased in step with productivity growth for many countries.[53] Since then, there has been a decoupling in the evolution of these two indicators, with the earnings of a typical family remaining flat or increasing less than productivity growth. The International Labour Organization has documented a similar decoupling for 52 developed economies, showing that from 1999 to 2017, labour productivity increased 17 percent while real wages rose 13 percent.[54]

Shifting economic power

The market power of firms can be manifested in their ability to charge prices above the cost of production or by paying lower wages than would be needed in an efficient labour market. There is evidence that both manifestations of market power are increasing, and even though technology is not the only element driving this shift, it is playing an important role.

There has been a sharp increase in markups (the difference between what a firm charges and the marginal cost of production), and this has been linked directly to labour's declining share in income.[55] While the trend of increased market power is widely shared across several sectors and industries, firms in sectors that intensively use information and communications technologies have witnessed faster, and greater, increases in markups (figure 6.6), suggesting that technology's relevance pervades across a wide range of firms.[56] Look now at big digital companies, commonly known as Big Tech, and explore how they have been acquiring market power.

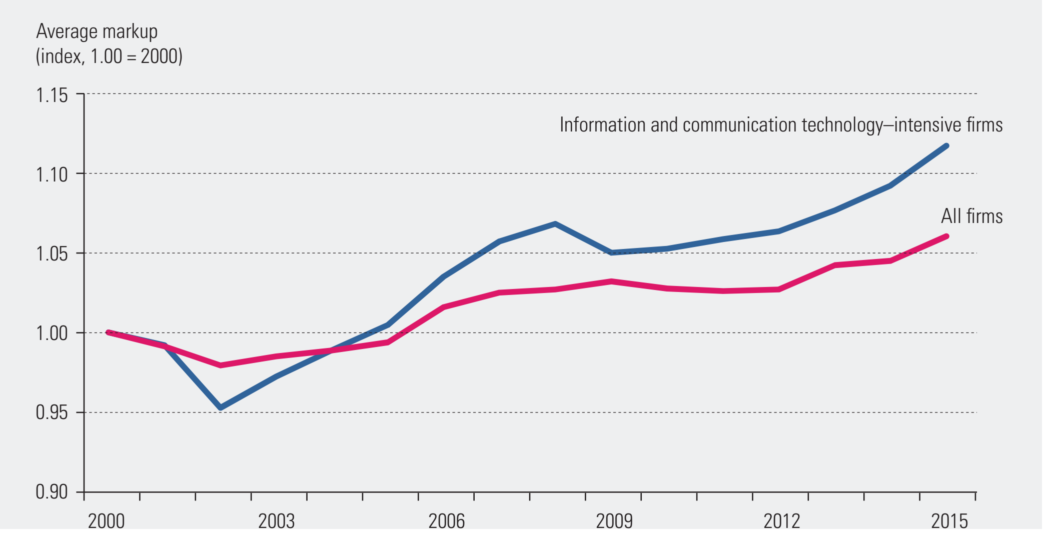
There has been a sharp increase in markups (the difference between what a firm charges and the marginal cost of production), and this has been linked directly to labour's declining share in income

Many Big Tech firms are platforms. Uber, the ride sharing company, is a platform where drivers offer their services and customers come looking for those services. Gojek and Grab work in the same way in Asia. Amazon is a platform linking sellers of products with potential buyers. All platforms benefit from network effects—that is, the value of the platform increases when there are more participants on both sides of the market. For Amazon the more sellers and the more buyers, the better for each group—and, of course, for Amazon as well.[57] Getting big supports staying big, since buyers are reluctant to leave a platform where they find sellers, and sellers, buyers. Social media companies such as Facebook and Instagram also benefit directly from network effects—people stay on the network where their friends and family are.

Big Tech intensively uses data and, increasingly, artificial intelligence, so another network spillover common to all platforms is economies of scale in data use, making these firms prone to acquiring market power.[58] Even though these platforms lower prices for consumers (and so, from that perspective, a more traditional measure of market power such as markups may not seem to apply), they can exercise market power by potentially limiting competition and choice.[59] The big players spend vast amounts on lobbying to influence policies that keep them in place and potential new entrants out.[60] And they can use their vast reserves of cash to simply buy up new platforms starting to make a mark. Google

FIGURE 6.6

Market power is on the rise, particularly for firms intensive in information and communication technology



Note: Values are average markups for firms from 20 countries, advanced and emerging, both publicly listed and privately held.
Source: Diez, Fan and Villegas-Sánchez 2019.

bought its competitors DoubleClick and YouTube. Facebook first acquired Instagram, then WhatsApp. Both companies, like others, are the products of hundreds of mergers.[61]

In parallel to the rise of monopoly power in product markets is the growing market power in labour markets—monopsony power (exercised by employers), which, once again, is linked to the decline in labour's share of income.[62] And when employers have power in labour markets, the impact of technological change on inequality can be magnified.[63]

In parallel to the rise of monopoly power in product markets is the growing market power in labour markets—monopsony power (exercised by employers), which, once again, is linked to the decline in labour's share of income

Technology is enabling monopsony power in online platforms that are carving out tasks to assign to humans based on who charges the lowest price. This includes work in digital labour markets such as TaskRabbit and Amazon Mechanical Turk, commonly referred to as crowdwork. The availability of online work may lower search costs, which would make markets competitive. But market power is high even in this large and diverse spot market. For Amazon Mechanical Turk, employers capture much of the surplus created by the platform. This has implications for distributing the gains from digital labour markets, which will likely become greater over time.[64] While crowdwork is a product of technological advances, it also represents a return to the past casual labour in industrialized economies, and in developing economies it adds to the casual labour force.[65]

The discussion here illustrates how technology is already shaping the distribution of income[66] and of economic power through rising markups, with firms exercising power at the expense of workers and consumers, as reflected in the declining share of labour income and the decoupling of median wages from labour productivity.[67] Further advances in technology, linked to advances in automation and artificial intelligence, could accelerate these dynamics,[68] while pushing to the limit existing frameworks to curb market power. The merit of antitrust action is still assessed primarily by how much consumer prices have risen.[69] But technology platforms are based on an exchange of user data for "free services." So there are calls to revisit current antitrust approaches and how to extend them to curb monopsony power.[70]

Harnessing technology for a Great Convergence in human development

This chapter started by asserting that avoiding another Great Divergence was a matter of choice—though that does not imply that the task will be easy. It ends with indications of how to exercise that choice and unleash a Great Convergence in human development. The focus will remain on digital and related technologies, guided by a broad set of principles linked to the implementation of the 2030 Agenda for Sustainable Development (box 6.2). It first provides a framework to analyse the impact of artificial intelligence and automation that suggests opportunities to generate demand for labour. The discussion also considers the challenges of artificial intelligence, including the potential to exacerbate horizontal inequalities, as well as the ethics of it. It then provides concrete illustrations of how technology can, in practice, reduce inequality, particularly addressing the divergence in enhanced capabilities identified in part I of the Report.

Automation, artificial intelligence and inequality: Will it be possible to increase the demand for labour?

Automation and artificial intelligence do not have to shrink the net demand for labour.[71] Automation can be leveraged to create new tasks—a reinstatement effect, which would counter the displacement effect.[72] The impact on inequality will depend on how technology changes the task content of production—whether it displaces or reinstates labour through the creation of new kinds of tasks. For example, jobs such as fulfilment centre worker, social media adviser and YouTube media personality did not exist a few decades ago. Technological advance also results in an overall increase in productivity, boosting the demand for all factors of production, including labour (figure 6.7). After elaborating on the potential of this framework to identify opportunities to use artificial intelligence to increase labour demand, the discussion moves towards some of broader risks associated with it.

Artificial intelligence's potential for reinstating work

In addition to the amount, it is important to consider the quality of work. Do the kinds of new tasks created through technology differ fundamentally from past ones? For example, the rise of platforms may push down the number of workers in brick-and-mortar retail stores while increasing the number employed in fulfilment centres preparing online orders for shipping.[73] Work available on platforms has introduced flexibility and extended work opportunities in some sectors but created challenges such as how to handle the large amount of data on workers, which poses risks for worker privacy and could have other consequences, depending on how the data are used.[74]

In addition to offering new work opportunities, platforms can enhance financial inclusion. This is happening in South-East Asia (where more than three-quarters of the population is unbanked) thanks to ride-hailing services such as Gojek and Grab.[75] Once drivers become part of these platforms, they get support to open bank accounts, and the apps have become vehicles to handle financial transactions, including

Automation can be leveraged to create new tasks—a reinstatement effect, which would counter the displacement effect

BOX 6.2

Digital technologies for the Sustainable Development Goals: Creating the right conditions

Digital technologies have transformational potential. Different actors at different levels have to participate for these applications to be taken to scale. Many applications are yet to be developed. Policies are needed—at the national and global levels—to provide the right incentives to developers and adopters of technology in the fields most beneficial for human development.

The UN Secretary-General established the High-level Panel on Digital Cooperation in July 2018 to identify examples of and propose ways for cooperating across sectors, disciplines and borders. Its final report made several recommendations under broad themes, such as build an inclusive digital economy and society; protect human rights and human agency while promoting digital trust, security and stability; and fashion a new global digital cooperation architecture.[1]

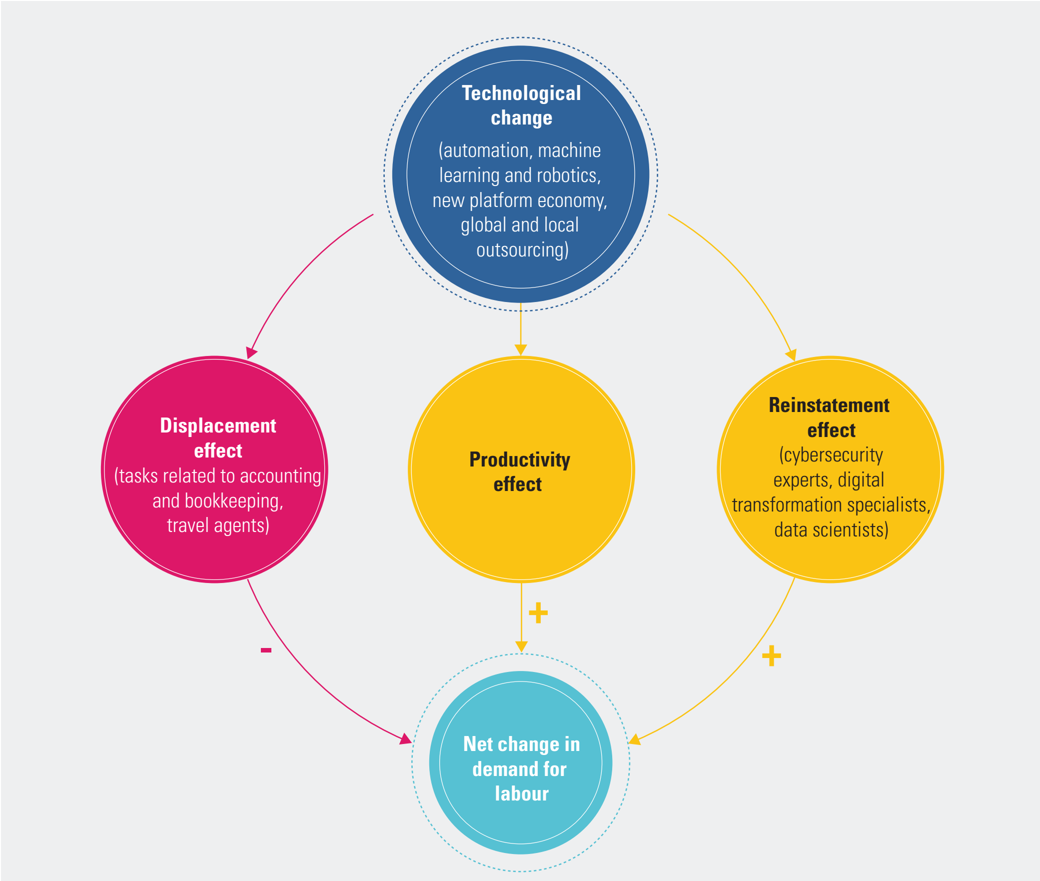
As a follow up to that report, the Global Charter for a Sustainable Digital Age provides a set of principles and standards for the international community, aiming to link the digital age with the global sustainability perspective. It sets out concrete guidelines for action for dealing with the challenges of the digital age.[2]

Notes

1. UN 2019a. 2. German Advisory Council on Global Change website (www.wbgu.de/en/publications/charter).

FIGURE 6.7

Technology can displace some tasks but also reinstate new ones



Source: Human Development Report Office.

cash. Incentives to adopt more formalized payment methods extend to retailers, such as food merchants using the platform to deliver to their customers.[76]

Basing the impact of artificial intelligence and automation on the assumption that technology could replace entire occupations can lead to high estimates of how many jobs are at risk.[77] An approach based on tasks (with occupations defined by a bundle of different tasks) provides a more balanced and more actionable framework to understand the impact—and potential—of artificial intelligence and automation. There is evidence that, within occupations, the possibility of tasks being replaced with artificial intelligence varies greatly, and different occupations have different resulting levels of susceptibility (table 6.1).[78]

Basing the impact of artificial intelligence and automation on the assumption that technology could replace entire occupations can lead to high estimates of how many jobs are at risk

Some occupations have several tasks that could be easily replaced by artificial intelligence bundled with other tasks that are difficult or impossible for machines to replace. A radiologist's task of checking medical images to identify anomalies can be performed by artificial intelligence, but a machine cannot set priorities, consult with the medical team, make treatment plans or communicate with patients and family—all tasks the radiologist performs. This suggests that when tasks within a job can be separated and rebundled, there is potential for job-redesign or job-crafting.[79] With the prevalence of highly accurate medical image recognition, radiologists can spend less time looking at images and more time interacting with other medical teams and with patients and family. Job-redesign and job-crafting thus offer opportunities to leverage artificial intelligence to increase labour demand.

The ability of artificial intelligence to identify patterns, relationships and trends and to automatically display them through interactive dashboards or create automated reports is constantly improving. This implies updated task structures for many jobs, including stock market traders, copywriters and even journalists and editors. While a lot of tasks will be automated, high-level management and oversight of automated systems tasks are less susceptible. However, an occupation's aggregate suitability for machine learning score is not correlated with wages.[80] So it is not inevitable that artificial intelligence will replace or depress wages in certain occupations, as some argue about previous waves of automation.[81]

A human-centred agenda thus requires attention to technology's broader role in advancing decent work. Technology can free workers from drudgery and arduous labour. There is even potential for collaborative robots, or cobots, to reduce work-related stress and injury. Realizing technology's potential in the future of work depends on fundamental choices about work design, including detailed job-crafting discussions between workers and management.[82]

Intelligence augmentation (using computers to extend people's ability to process information and reason about complex problems) means that artificial intelligence, instead of aiming at automation, can integrate human agency and automation in a way that enhances both. The augmentation can take place in everyday human tasks. This happens already in spelling and grammar checking in word processors, which highlight text to correct errors, and in autocompletions of text input in internet search engines. Automatic suggestions, easily dismissible, can accelerate the search and refine ambiguous queries. These provide value, promoting efficiency, accuracy and the consideration of alternate possibilities. They augment, but do not replace, user interaction.[83]

Finally, the recent advances in artificial intelligence do not increase artificial general intelligence that could substitute machines for all aspects of human cognition. Artificial intelligence has been very effective at one aspect of intelligence: prediction.[84] But prediction is only an input into decisionmaking. The decision task is broader, requiring the collection and organization of data, the ability to take an action based on a decision and the judgement to evaluate the payoffs associated with different outcomes. For individual workers, advances in artificial intelligence will matter to the degree that prediction is a core skill in the tasks that make up their occupation. The diagnosis that a radiologist provides can also be partially made by artificial intelligence, but that is very different from a decision on the course of treatment or its implementation by a surgeon. Automated prediction thus enhances rather than replaces the value of these occupations.

TABLE 6.1

Different tasks have different potential for being replaced by artificial intelligence

Occupations with low suitability for machine learning	Suitability for machine learning score	Occupations with high suitability for machine learning	Suitability for machine learning score
Massage therapists	2.78	Concierges	3.90
Animal scientists	3.09	Mechanical drafters	3.90
Archaeologists	3.11	Morticians, undertakers and funeral directors	3.89
Public address system and other announcers	3.13	Credit authorizers	3.78
Plasterers and stucco masons	3.14	Brokerage clerks	3.78

Source: Brynjolfsson, Mitchell and Rock 2018.

Realizing technology's potential in the future of work depends on fundamental choices about work design, including detailed job-crafting discussions between workers and management

Exercising choices to seize on technology's potential: Balancing risks and opportunity

After establishing artificial intelligence's potential to reinstate work, this section elaborates on elements to consider in seizing the opportunities that artificial intelligence, and technology more broadly, are presenting. Doing so implies also having a clear-headed perspective on risks. For instance, artificial intelligence can accentuate biases and horizontal inequalities (box 6.3), including exacerbating gender disparities in the workforce, leading to even more women being in low-quality service jobs.[85] Women, on average, perform more routine or codifiable tasks than men and fewer tasks requiring analytical input or abstract thinking.[86] These differences are also present in gender gaps in education and employment linked to technology.[87] LinkedIn

BOX 6.3

Artificial intelligence and the risk of bias: Making horizontal inequalities worse?

Artificial intelligence applications have the potential to support positive social change—indeed, in some domains their impact could be revolutionary. But as with any new technology, actually achieving these positive results is challenging and risky.

Many groups of people across the globe may be on the receiving end of artificial intelligence's downside. They may lose their jobs as more tasks are performed by machine learning—even if net job loss is contained, inequalities in income and wealth could rise, and the quality of jobs fall. Workers may see strong biases against their skin colour or gender embedded in machine learning, and they may be subjects of surveillance. Algorithms for job matching may reproduce historical biases and prejudices. Companies need policies on transparency and data protection so that workers know what is being tracked. Regulation may be needed to govern data use and algorithm accountability in the world of work.

As uses of artificial intelligence become pervasive, questions arise about the rise of propaganda and manipulation, undermining democracy, and about surveillance and the loss of privacy. For example, artificial intelligence applications are linked with the development of smart cities.[1] This involves collecting data from cameras and sensors on a large scale. How does this differ from mass surveillance?

Machine learning algorithms are not biased inherently; they learn to be biased. Algorithmic bias occurs when the learning algorithm is trained on biased datasets and subsequently "accurately" learns the patterns of bias in the data.[2] In some cases the learned representations within machine learning algorithms can even exaggerate these biases.[3] For example, women are less likely to receive targeted ads for high-paying jobs potentially because the algorithm that targets the ads trained on data in which women had lower paying jobs.[4] And a computer programme used in the United States to assess the risk of reoffending by individuals in the criminal justice system incorrectly flagged black defendants as high risk nearly twice as often as white defendants.[5]

Facial recognition services can be much less accurate in identifying women or people with darker skin.[6]

The well recognized lack of diversity among the people designing and developing artificial intelligence is another problem. Few women work in artificial intelligence, as in the tech sector in general, and among the men, racial diversity is limited.[7] Diverse teams, bringing diverse perspectives, representative of the general population, could check biases.

Notes

1. Glaeser and others 2018. 2. Caliskan, Bryson and Narayanan 2017; Danks and London 2017. 3. Zhao, Wang and others 2017. 4. Spice 2015. 5. IDRC 2018. 6. Boulamwini and Gebru 2018. 7. IDRC 2018.

LinkedIn and the World Economic Forum found a significant gap between female and male representation among artificial intelligence professionals—only 22 percent worldwide are female

and the World Economic Forum found a significant gap between female and male representation among artificial intelligence professionals—only 22 percent worldwide are female.[88] Racial and ethnic differences among women in access to training and employment opportunities can exacerbate these disparities. Artificial intelligence and technology more broadly developed by teams that reflect a country's population can counter such risks. When teams are not diverse, artificial intelligence will tend to be trained on data that may have built-in biases that a more representative environment could avoid.

Researchers, firms and governments are responding to manage the risks of artificial intelligence—which include accentuation of biases as well as development of deceptive and malicious applications. For instance, thousands of artificial intelligence researchers have signed an open letter stating that they will oppose autonomous weapons, which search and engage targets without human intervention.[89] Many companies—from Big Tech to startups—are formulating corporate ethical principles overseen by ethics officers or review boards. Still, it is unclear how accountable they will hold themselves to the principles—which points to the need for regulation.[90] Governments increasingly use artificial intelligence themselves, and some are developing data ethics principles (box 6.4). When artificial intelligence systems inform decisionmaking that affects humans (such as medical diagnosis or providing a judge with an assessment of potential recidivism), avoiding bias and errors across different contexts and communities is especially important. And given the global application and reach of many artificial intelligence innovations, collective action may be needed at some point on some regulatory aspects.

BOX 6.4

The United Kingdom's Data Ethics Framework principles

1. *Start with clear user need and public benefit.* Using data in more innovative ways has the potential to transform how public services are delivered. We must always be clear about what we are trying to achieve for users—both citizens and public servants.
2. *Be aware of relevant legislation and codes of practice.* You must have an understanding of the relevant laws and codes of practice that relate to the use of data. When in doubt, you must consult relevant experts.
3. *Use data that is proportionate to the user need.* The use of data must be proportionate to the user need. You must use the minimum data necessary to achieve the desired outcome.
4. *Understand the limitations of the data.* Data used to inform policy and service design in government must be well understood. It is essential to consider the limitations of data when assessing if it is appropriate to use it for a user need.
5. *Ensure robust practices and work within your skillset.* Insights from new technology are only as good as the data and practices used to create them. You must work within your skillset recognising where you do not have the skills or experience to use a particular approach or tool to a high standard.
6. *Make your work transparent and be accountable.* You should be transparent about the tools, data and algorithms you used to conduct your work, working in the open where possible. This allows other researchers to scrutinise your findings and citizens to understand the new types of work we are doing.
7. *Embed data use responsibly.* It is essential that there is a plan to make sure insights from data are used responsibly. This means that both development and implementation teams understand how findings and data models should be used and monitored with a robust evaluation plan.

Source: UK Department for Digital, Culture, Media and Sport 2018.

A broader set of disruptions to the world of work, powered in part by artificial intelligence, is linked to digital labour platforms—alluded to earlier. These applications allow the outsourcing of work to geographically dispersed people, generating crowdwork. While they provide new sources of income to many workers in different parts of the world, the work is sometimes poorly paid, and no official mechanisms are in place to address unfair treatment. Compensation for crowdwork is often below the minimum wage.[91] True, much policy innovation is already under way, with subnational regulators stepping up.[92] But the dispersed nature of the work across international jurisdictions makes it difficult to monitor compliance with applicable labour laws. That is why the International Labour Organization suggests developing an international governance system for digital labour platforms that sets minimum rights and protections and requires platforms (and their clients) to respect them.[93]

Providing social protection

A related challenge is providing social protection to help address both the adverse impact of technology disruptions on specific income groups and the resistance to those changes.[94] During adjustments, vulnerable workers typically face periods of unemployment or see their earnings eroded. But if technology changes rapidly, it might be more challenging to find decent jobs in a new techno-economic paradigm[95] than after a more "standard" economic recession. Social insurance programmes can provide affected workers with sustenance during transition periods, but the nature of the transition matters as well: Sectors and locations where the displacement effect is stronger may need targeted social protection schemes.[96]

Active labour market policies—including wage subsidies, job placement services and special labour market programmes—can facilitate adaptation to a new techno-economic paradigm. The ideal would be a social protection floor that affords a basic level of protection to all in need, complemented by contributory social insurance schemes that provide increased protection.[97] The design of these systems presents policymakers with choices ranging from ensuring coverage at the bottom while curbing leakage to the better off[98] to balancing the generosity of transfers and the losses in efficiency[99] and ultimately to assessing the fiscal cost

Compensation for crowdwork is often below the minimum wage against alternative uses.[100] Narrowly targeted policies could include measures to facilitate geographic mobility, supporting housing and moving costs,[101] particularly if technology creates jobs in one region while contributing to their elimination in others.

Ultimately, social protection will be only part of the response, because workers whose jobs are partially or fully automatable will need to adjust to substantially changed or entirely new occupations. Since automation affects some tasks and creates others, the nature and content of jobs change constantly. And this requires workers to learn throughout their lives. Artificial intelligence and automation tend to make high-skilled workers more valuable and in demand. There is evidence that those are the workers who avail themselves of lifelong learning opportunities, while participation among low-skill, low-wage workers is much lower (figure 6.8). Thus, there is a risk of patterns of divergence emerging in workplace and lifelong learning that are similar to those in enhanced capabilities. Lifelong learning risks creating a wedge by enabling the highly skilled to race further ahead.[102]

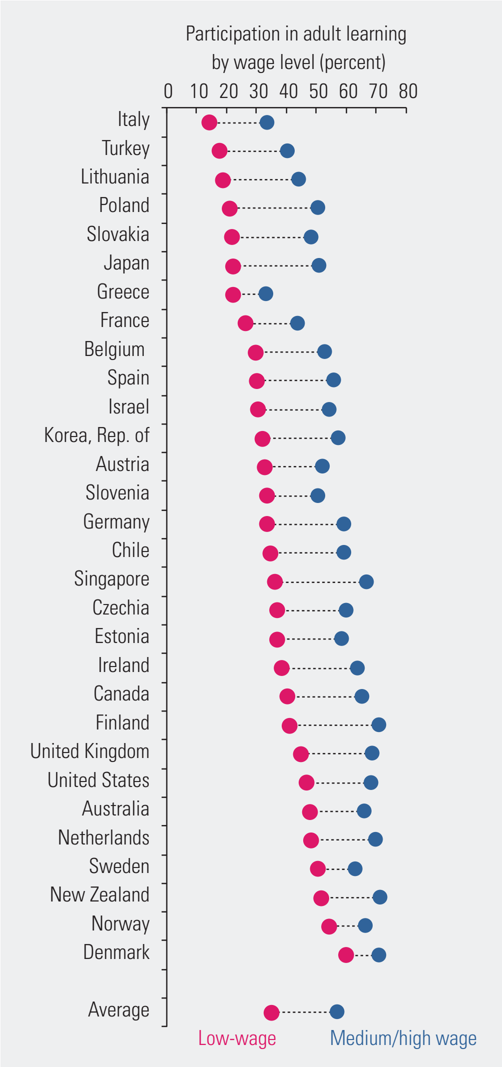
Taxation and data regulations

Beyond the impact of artificial intelligence on labour markets, two systemic challenges and risks merit particular attention: taxation and data regulation. As the potential for machines to replace tasks performed by humans grows, some have argued that there is an efficiency rationale for taxing robots[103] and for channelling technology to reinstate, rather than replace, labour.[104] In addition, digitally intensive economic activities, where the value of companies is linked less to their physical presence in a country and more to the number of members of networks around the world, are challenging longstanding assumptions underlying principles of taxation. Some proposed actions and ideas serve the interest of particular tax jurisdictions,[105] but given that digital activities are global and many companies operate across borders, there is a clear need for an international consensus on how to tax digital activities, and efforts to broker such an international agreement are under way.[106]

Data are at the centre of the digital economy. Whether targeting ads, managing supply chains or deciding the placement of drivers waiting for rides, the revenues of more and more firms are tied to collecting and analysing huge amounts of data. The free flow and use of data are important for businesses and governments. But there is also a need to protect personal data, data embodying intellectual property and data related to national security. For now the ownership and use of data are governed mostly by default norms and rules. But many jurisdictions at different levels are working out data policies to ensure that advances in innovation also protect users.[107] European governments,

FIGURE 6.8

Workers in medium and high wage jobs are more likely to participate in adult learning



Source: OECD 2019c.

through the European Union's General Data Protection Regulation, have instituted data privacy rules.[108] Beyond regulation are proposals to pay users for their data, to spread the wealth generated by artificial intelligence. Firms could generate better data by paying. Data-providing labour could come to be seen as useful work, conferring the same sort of dignity as paid employment.[109]

Deploying technology as a force for convergence in human development

For education to drive convergence implies preparing young people today for the world of work of tomorrow. Technology can help, for instance, in enabling individually customized content to "teach at the right level." This is especially important because the rapid expansion of access to primary and secondary education in developing countries has led to the enrolment of millions of first-generation learners. If they fall behind and lack instructional support at home, they may learn very little in school.[110] One example of how technology can help in middle school grades is a technology-led instructional programme called Mindspark used in urban India. It benchmarks the initial learning level of every student and dynamically personalizes material to match the individual's level and rate of progress. In just 4.5 months those with access to the programme scored higher in math and in Hindi.[111] In partnership with the programme, India's government is providing a personal learning platform called Diksha. Pointing a cell phone at a printed QR code opens a universe of interactive content—lesson plans for teachers and study guides for students and parents.[112]

Digital health solutions can also drive convergence. Still in their early days, they show the potential for expanding service coverage. Services include digitizing supply chains and patient data, with integrated digital platforms for information, bookings, payments and complementary services. They are important in areas that are remote and that have inadequate access to health care providers. Artificial intelligence is already taking hold, for example, in machine pattern recognition for medical scans and skin lesions.[113] There is also potential for machine learning to aid personalized nutrition.[114] And with the availability of real-time objective data on mood—from smartphone keystrokes, for example—artificial intelligence can help mental health diagnosis. Elderly care providers are starting to offload some parts of care to artificial intelligence, from early diagnosis of disease to at-home health monitoring and fall detection.[115] Artificial intelligence has also been used to pore through genetic data to discover that a shortage of the element selenium could be associated with premature births in Africa.[116]

Applications of artificial intelligence extend beyond education and health to other public services, leading not only to greater efficiency and enhanced transparency, but also to broader participation in various aspects of public life. For example, linguistic diversity, a given in most countries, can make e-governance services inaccessible for entire groups. In South Africa, with 11 official languages, the Centre for Artificial Intelligence Research is working on machine translation approaches to broaden access to government services.[117] In Uganda the AI Research Group at Makerere University is developing source datasets for some of the dozens of languages spoken there.[118]

The potential returns are huge in service delivery during and after disasters. Artificial Intelligence for Disaster Response is an open-source project that applies artificial intelligence to mine, classify and tag Twitter feeds during humanitarian crises, turning the raw tweets into an organized source of information that can improve response times. Soon after Ecuador experienced a major earthquake in 2016, Zooniverse, a web-based platform for crowd-sourced research, launched a website that combined inputs from volunteers and an artificial intelligence system to review 1,300 satellite images and, two hours after the website's launch, produced a heat map of damages.[119]

For social protection, technology is helping in targeting payments and other benefits, providing timely delivery and reducing opportunities for fraud. Public platforms that support interoperability and data exchange can reduce the administrative burden and the time to deliver services to poor, vulnerable and marginalized groups, promoting social and economic inclusion.[120]

Technology can help, for instance, in enabling individually customized content to "teach at the right level"

The direction of technological change can be an explicit concern for policymakers

Technology can also improve the availability of data and information for policymakers and businesses—and inform public debate. For instance, as digital imagery becomes ubiquitous and machine vision techniques improve, automated systems lend themselves to measuring demographics with fine spatial resolution in close to real time.[121] The same applies to measuring poverty and other social and economic indicators, often combining mobile phone data and satellite imagery, with the use of multiple lenses obtained from diverse datasets helping capture information on living standards more accurately.[122] For instance, in Senegal the Multidimensional Poverty Index can be accurately predicted for 552 communes using call data records and environmental data (related to food security, economic activity and accessibility to facilities). This approach can generate poverty maps more frequently, and its diagnostic capability is likely to assist policymakers in designing better interventions to eradicate poverty.[123]

In the same way that artificial intelligence can chart individualized learning paths for students, artificial intelligence's potential to collect detailed and frequent data can be leveraged to obtain very specific localized information.[124] For instance, using an artificial intelligence algorithm to analyse weather and local rice crop data in Colombia[125] led to distinct recommendations for different towns, helping 170 farmers in Córdoba avoid direct economic losses estimated at $3.6 million and potentially improving rice production. Other applications include using cutting-edge artificial intelligence to tackle urban challenges related to traffic, safety and sustainability. These applications range from artificial intelligence traffic management[126] to artificial intelligence systems that locate pipes at risk of failure.[127] Global telecommunication networks and cloud services can enable artificial intelligence insights to be transferred and adapted in different contexts.[128] Sharing artificial intelligence results among machines enables transfer learning,[129] through which knowledge moves and is customized into new contexts,[130] supplementing resources in previously underserved areas.

* * *

The direction of technological change can be an explicit concern for policymakers.[131] Recall that the public sector has supported fundamental research for technology that was subsequently commercialized by the private sector.[132] Technological innovation will be crucial to meet the Sustainable Development Goals.[133] Harnessing technology for that purpose calls for all countries to shape global and national institutions and policies that will determine the impact of technological change on sustainability and inclusion in a way that is nationally relevant.[134] It is in this context that international intellectual property rights matter. An overly stringent intellectual property rights regime can make technology diffusion harder (box 6.5).

The successful generation, diffusion and adoption of technology for development take place in a network of multiple actors—including the private sector, government and academia, often referred to as a national innovation system.[135] Public policies to influence the direction of technology are nested in such systems. Across countries, there are enormous asymmetries in the size and organization of innovation efforts. Research and development are still more intensive in developed countries (figure 6.9), and on average the gap with other countries is widening, but at the same time new regions are emerging as scientific and technological powerhouses, as in East Asia.

Important in the ability to invest nationally in science and technology, the diffusion of innovation will remain a powerful driver to increase productivity. Enhancing the productivity and employability of every worker—reaching those currently in informal and precarious forms of employment and excluded from more modern productive systems—will tend to reduce income inequality while increasing incomes.[136]

For this mechanism to work, workers must be able to use technology and benefit from the rise in productivity. Between 2007 and 2017 the median income in many countries grew less than productivity per worker, even though income and productivity are strongly correlated (figure 6.10, left panel). Moreover, the higher the productivity, the greater the share of productivity that the median worker receives as compensation (see figure 6.10, right panel). Decoupling median labour income from productivity implies that increasing productivity

BOX 6.5

Intellectual property rights, innovation and technology diffusion

In principle, intellectual property rights can be a powerful driver to incentivize innovation and creativity, even if they impose temporary restrictions on free access to new knowledge. But in some cases they have generated patent thickets, patent trolls and evergreening[1]—potentially curbing not only diffusion, but also innovation itself. Patent thickets imply long and costly negotiations to obtain multiple permissions. Patent trolling—where innovators face suits from others who own intellectual property simply to profit by licensing patents rather than undertaking production themselves—is costly.[2] And evergreening—where companies extend their patent protection by inventing new follow-on patents that are closely linked but allow for a longer period of monopoly than would otherwise be permitted—curbs competition.

On balance, while weak patent systems may increase innovation only mildly, strong patent systems can slow innovation.[3] In the last few decades a higher concentration of patent ownership, echoing the broader pattern of market concentration, has contributed to declines in knowledge diffusion and business dynamism.[4]

Under the World Trade Organization Trade Related Aspects of Intellectual Property System, developing countries are encouraged to increase the level and stringency of their intellectual property provisions in order to enhance international transfers of technology and spur innovative domestic firms.[5] The point is that intellectual property protection will give them the right to the profits from research and development breakthroughs. But country case studies show mixed evidence of intellectual property rights being important for foreign investment inflows, domestic technological development or technology transfers.[6]

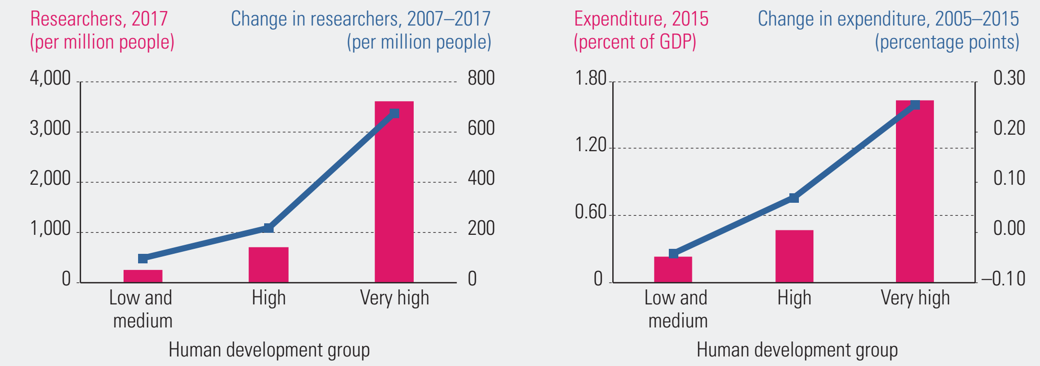
Assigning patents to a shell company in a low tax country, paying royalties on their own patents to the shell companies and parking the income offshore illustrates how intellectual property rights can be used for tax avoidance.[7] These mechanisms further concentrate income, wealth and market power. Here, as in other areas, economic institutions and laws created in the 20th century to manage industrialization in developed economies may need to be reconsidered in the 21st century.

Notes

1. Baker, Jayadev and Stiglitz 2017. 2. Bessen and Meurer 2014. 3. Boldrin and Levine 2013. 4. Akcigit and Ates 2019. 5. Baker, Jayadev and Stiglitz 2017. 6. Maskus 2004. 7. Dharmapala, Foley, and Forbes 2011; Lazonick and Mazzucato 2013.

FIGURE 6.9

There are enormous asymmetries in research and development across human development groups



Source: Human Development Report Office calculations based on data from the World Bank's World Development Indicators database.

FIGURE 6.10

Income and productivity are strongly correlated, and the higher the productivity, the greater the share of productivity that the median worker receives as compensation

Source: Human Development Report Office calculations based on data for 94 countries from the International Labour Organization.

Technology diffusion matters not only for incomes, but also for addressing other challenges, including those related to climate change

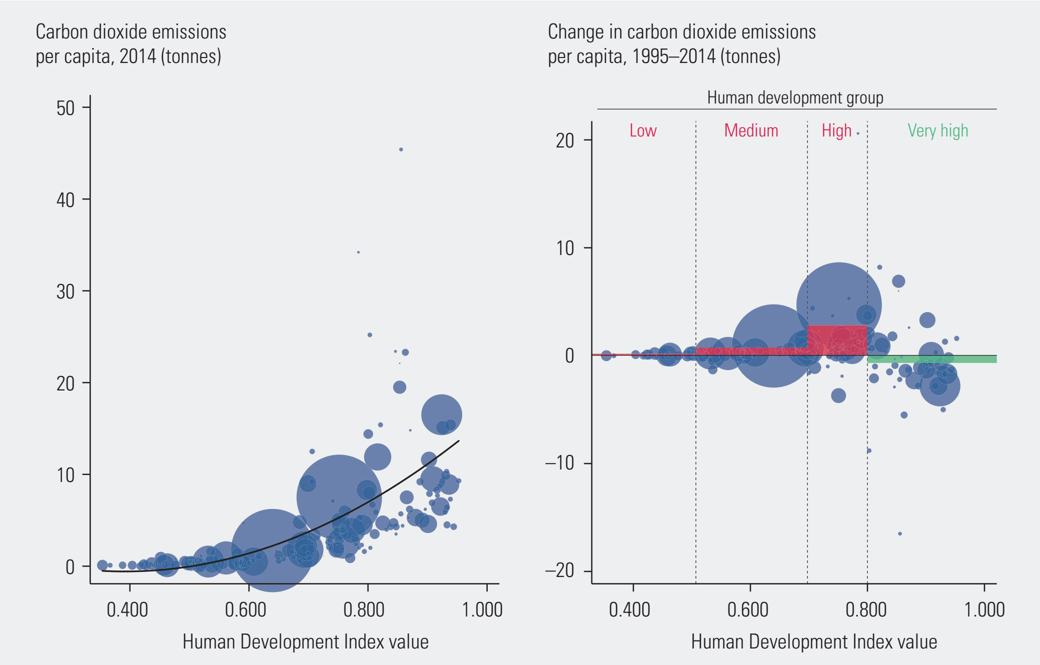
is not enough to increase wages, as discussed earlier.[137] But higher productivity can push the envelope for greater absolute compensation and for a more balanced distribution between workers and capital owners—and much of this push towards higher productivity depends on technology diffusion.

Technology diffusion matters not only for incomes, but also for addressing other challenges, including those related to climate change (chapter 5). Technological inequality between developing and developed countries harms developing countries' potential to move beyond traditional patterns of production and consumption.[138] A significant decoupling of emissions from economic development is taking place, and over the last decade several countries—predominately Organisation for Economic Co-operation and Development members with very high human development—have been reducing their carbon dioxide emissions per capita, reflecting more efficient forms of production (figure 6.11).[139] Technology diffusion will be key to extending that decoupling to countries at all levels of development.

This chapter has examined the distribution of enhanced capabilities related to technology. There is potential for harnessing technology for convergence in human development. At the same time, there is a possibility that these technologies end up causing more divergence. Making the right choices and policies, in this area and more broadly, are the topic of chapter 7.

FIGURE 6.11

A significant decoupling of emissions from development has allowed some countries to reduce their carbon dioxide emissions, reflecting more efficient forms of production



Note: Each bubble represents a country, and the size of the bubble is proportional to the country's population.
Source: Human Development Report Office based on data from the World Bank's World Development Indicators database.