CHAPTER 2

Expanding opportunities

Digital technologies can improve overall welfare and reduce poverty, but without complementary investments, they can also worsen inequality. In Africa alone, 11 million youth are expected to enter the labor market every year for the next decade.[1] Born in the internet era, they live in a world full of new and exciting opportunities.[2] Farmers use mobile phones to get price information and technical advice. Women facing barriers to work outside their homes can work online and better balance work and family. And many have found earning opportunities through online work and the on-demand economy. But these new opportunities come hand in hand with fundamental and rapid changes in the world of work, as digital technologies increase the demand for advanced skills, and many skills quickly become obsolete. From a technological standpoint, fewer than half of today's schoolchildren in China, Croatia, or Thailand can expect to find a job in an occupation that exists today.[3] But more than jobs disappearing, they will be transformed. The challenge for policy makers is to ensure that *all* current and future workers can seize the growing economic opportunities that accompany the spread of digital technologies. The risk is that rapid technological change will end up increasing inequality and leaving many behind—blunting the digital dividends.

The potential gains from technological progress for workers and consumers in developing countries are indeed large. Digital technologies can create jobs and increase earnings in the small information and communication technology (ICT) sector—and much more in the sectors that use ICT. They also increase worker productivity by augmenting human capital and—especially critical for the poor—connecting people to work and markets. And they can benefit consumers by lowering prices and expanding the variety of goods and services available, thus producing consumer surplus. Most of these consumer gains come from lower marginal production and distribution costs when firms innovate and automate processes, or from fully digital goods and services that allow firms to exploit economies of scale (figure 2.1 and spotlight 1).

But not everyone stands to benefit automatically. Only by improving internet access and basic literacy and updating skill and training systems will the benefits be realized and broadly shared. For the world's poor, the key is to leverage digital technologies to improve the productivity of household enterprises, subsistence family farmers, and the informal sector. Yet for every person connected to the internet in developing countries, almost three are not; among the poor, more than six are not; and many also lack access to such complementary infrastructure as electricity or roads. Even if connected, many cannot read or use the information the internet provides. For workers in more organized labor markets, conditions are changing rapidly. New jobs require different skills from old jobs, and many new jobs are informal or nonwage, without benefits or worker protections. Greater computer power and internet connectivity make some skills obsolete by substituting for work that is codifiable and routine, and thus can be automated. The remaining tasks require complex skills that complement technology, such as creativity, critical thinking, and problem solving. These skills remain hard for technology to emulate, but also for education and training systems to provide, leaving many workers unprepared for the modern world of work.

Thus while digital technologies can raise productivity and enhance overall welfare, associated labor market disruptions can be painful and can result in higher inequality. High-skilled workers are the biggest winners when paired with digital technologies. Globally, returns to education remain high, at 10 percent per year, and are even higher for those using technology at work. The poor, with no access to technology and lacking skills, see few of the direct downsides from technological adoption but also only partial benefits.

But it is the middle class that can be hollowed out as jobs held by this segment—often medium skilled—are transformed, partly driven by technological change. Machine operators and clerical support workers, for example, perform many "routine" tasks that are easily automated. Since 1995, the share of routine employment in total employment has fallen by 8 and 12 percentage points in developing and developed countries, respectively.[4] Such medium-skilled jobs, critical to the growth of the middle class and held disproportionately by the bottom 40 percent of the welfare distribution, give way either to high-skilled jobs that only a small share of workers qualify for, or to low-skilled jobs that face increasing competition and most likely declining wages.

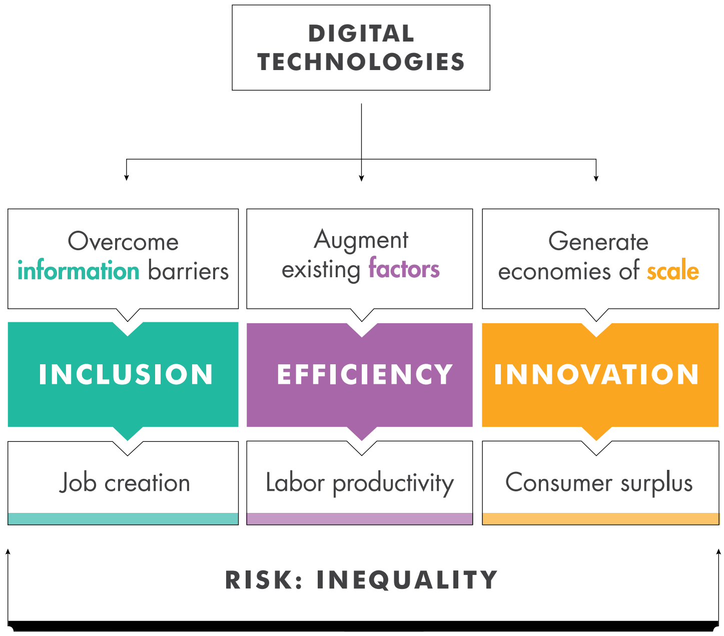
So the race is on between skills and technology, and the outcome will determine whether the dividends from digital technologies are realized and the benefits widely shared. It is important to bridge the digital divides both in access and in capabilities. This second divide separates the digitally savvy, who can make productive use of digital technologies and have skills that complement them—and the digitally poor, who remain unconnected and unskilled. Providing current and future workers with the cognitive, technical, and socioemotional skills that are augmented by technology—and not replaced by it—is a priority. Given the fast pace of technological change—with more intense job creation, destruction, and reallocation to be expected—labor regulations, taxation, and social protection systems will have to support labor mobility and adapt to the changing nature of work. This is the analog foundation for workers to succeed in a digital world.

Connected people

The world is more connected than ever. On average, 8 in 10 people in the developing world own a mobile phone (map 2.1). Digital technologies, often low-end phones, connect the more than 60 percent of the world's people who did not have a landline phone as late as 2000. More people have access to a mobile phone than to secondary schooling, clean water, or sanitation.[5] Internet adoption lags behind mobile phone access, but has tripled since 2005. In developing countries today, 28 percent of the population reports access to the internet at home, and in advanced economies, 80 percent.[6, 7]

Mobile phones are driving this interconnectedness, especially among the poor. All regions are converging in mobile phone use, but South Asia and Sub-Saharan Africa lag far behind in internet access

Figure 2.1 A framework for the internet and economic opportunities



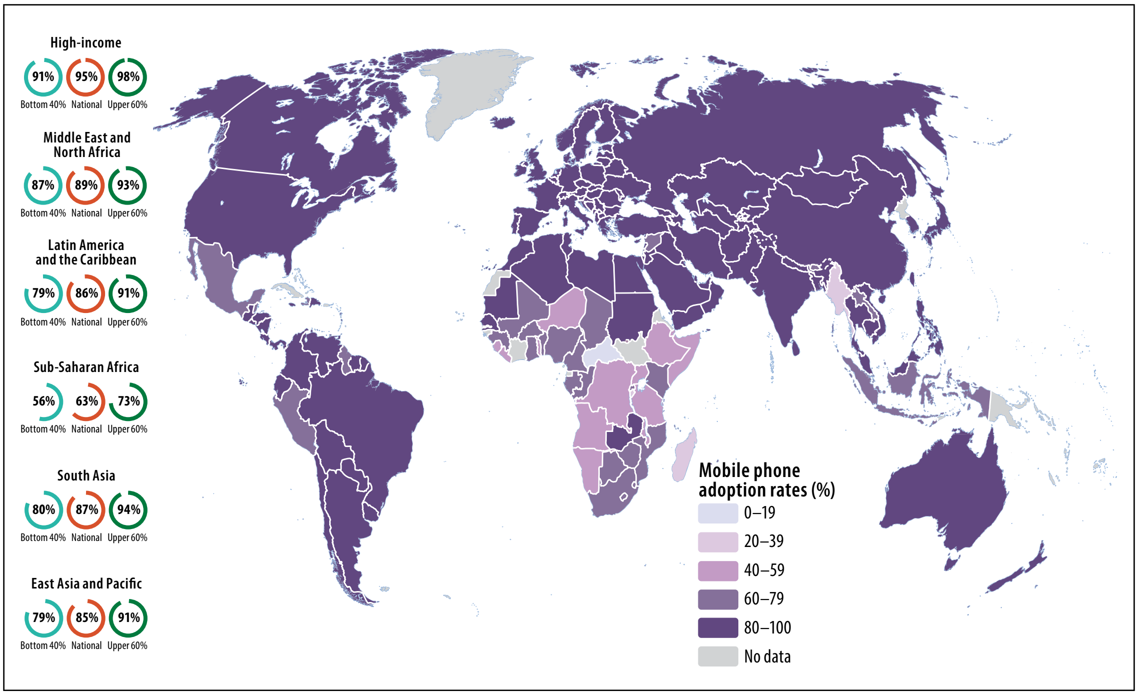
Source: WDR 2016 team.

(figure 2.2). A technology diffuses rapidly when it is low in cost, easy to use, has high potential benefits, and fits well with the local context. Low-cost mobile phones—which can be shared, prepaid, billed in prices per second, and do not require much literacy or numeracy for basic use—fit this description, and are the technology of choice among the poor.[8] In Cameroon, Ethiopia, Rwanda, Tanzania, and Uganda, more than four in five mobile phone owners have simple phones, not capable of browsing the internet.[9] Personal computers and the internet, by contrast, require literacy and often foreign language (especially English) skills. Computers with internet capabilities in the Warana subdistrict in Maharashtra, India, for instance, went largely unused except for transmitting market information to farmers—a function later substituted by mobile phones, which were cheaper and easier to use.[10]

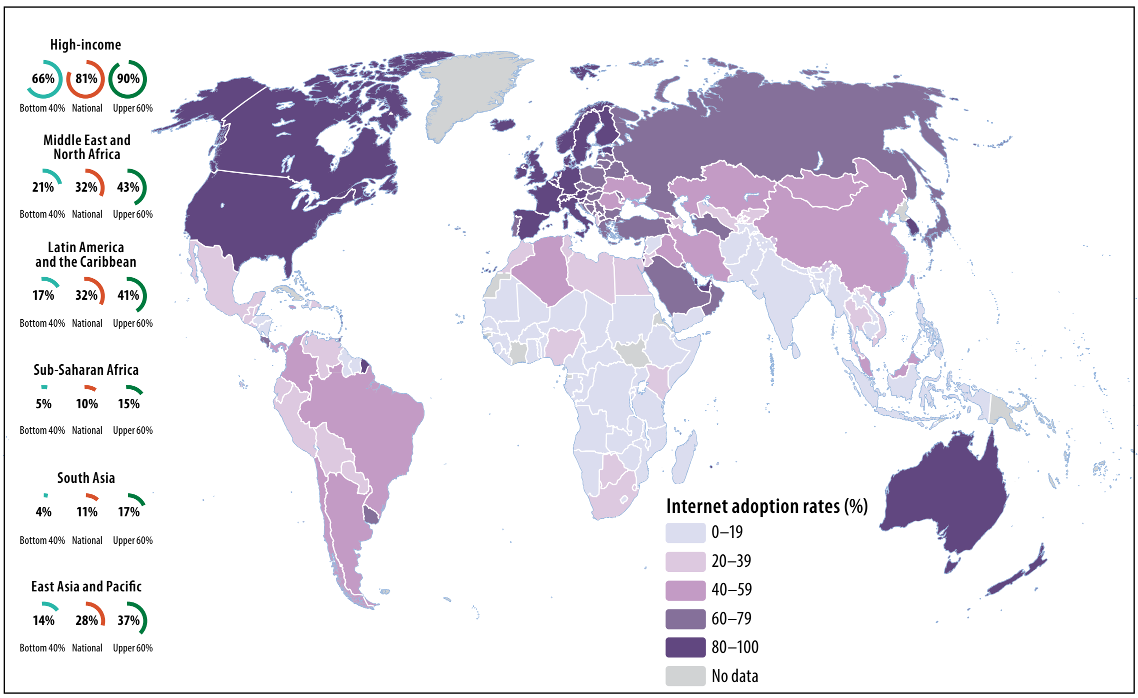
Communications, entertainment, and searching for information are the most common uses for mobile phones and the internet. In African countries, social networking, sending and receiving e-mails, instant messaging, and checking facts and definitions are the most common uses of the internet (figure 2.3). This is similar in Argentina, Brazil, Colombia, Mexico, Uruguay, and the European Union countries, especially with social networking (between 50 and 80 percent of all internet users).[11] The use of digital technologies

Map 2.1 Mobile phones are the main source of connectivity in the developing world, but large gaps in internet access remain

a. Mobile phone adoption rates, circa 2014



b. Internet adoption rates, circa 2014



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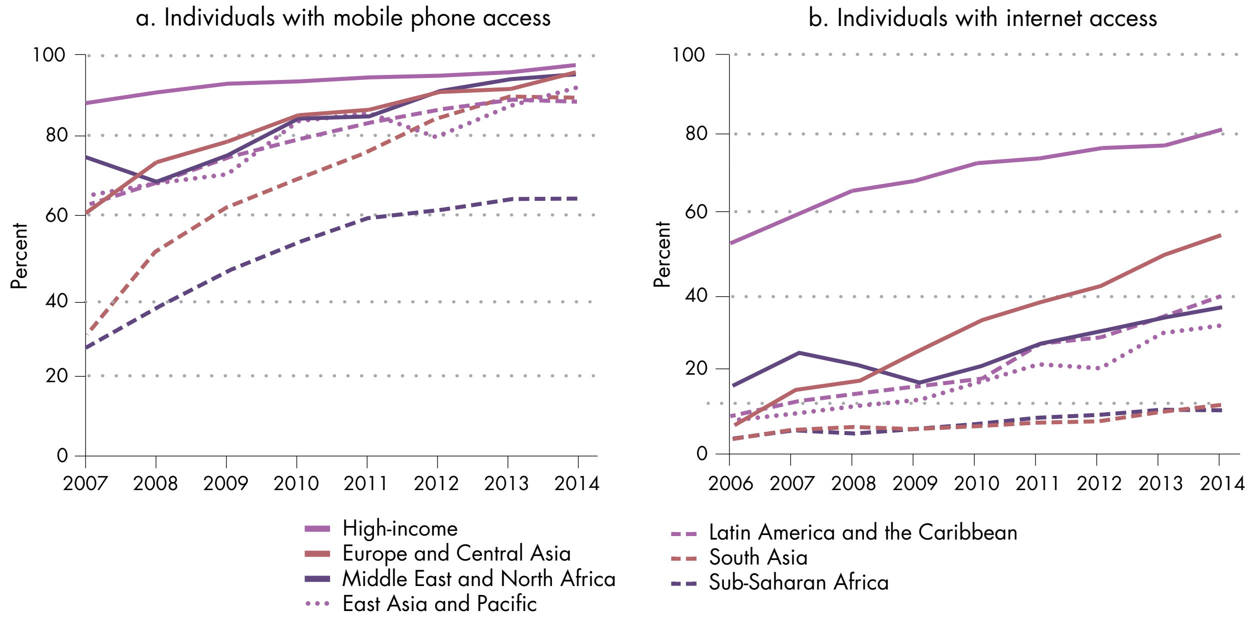
Source: WDR 2016 team, based on Gallup World Poll, various years. Data at http://bit.do/WDR2016-Map2_1.

Note: Adoption rates refer to the percentage of individuals who report owning a mobile phone (panel a) and having internet access at home (panel b).

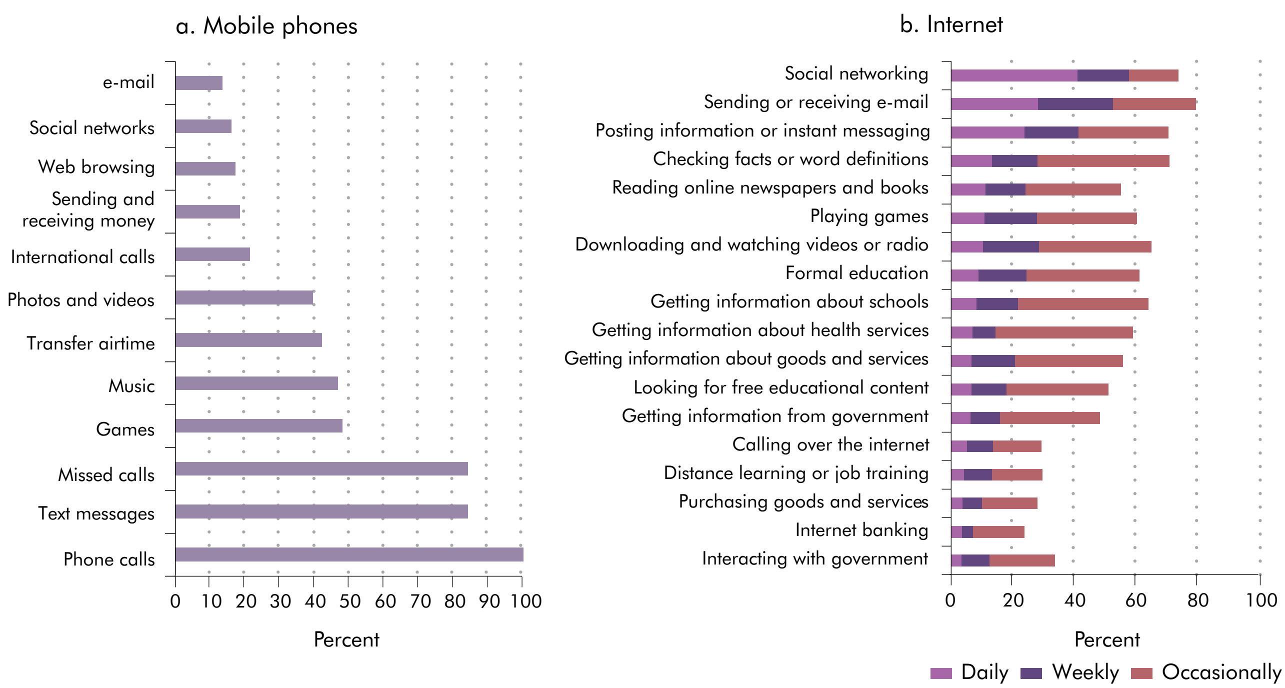
Figure 2.2 All regions are converging in mobile phone access, but South Asia and Sub-Saharan Africa are falling behind in internet access



Source: WDR 2016 team, based on Gallup World Poll, various years. Data at http://bit.do/WDR2016-Fig2_2.

Figure 2.3 How people use mobile phones and the internet in Africa

Percentage of individuals who use mobile phones or internet reporting each type of use, 2011–12



Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_3.

Note: Data are simple averages across 12 African countries.

for work, education, and health is more limited but increasing. Across the European Union, around 60 percent of internet users search for health information, and 13 percent make appointments with health practitioners online.[12] In Brazil, 60 percent of internet users use it for educational purposes, and in Mexico, 35 percent.[13] One in four individuals who use the internet in African countries reports doing so to get health and education information.[14] Uses vary across population groups. In Brazil and Mexico, women, rural, and poorer populations are less likely to use the internet for financial transactions or dealing with public authorities, but in both countries these same groups are equally or more likely to use it for educational purposes than men, urban, and richer populations.[15] Across countries, children and youth are most likely to use the internet for education.

The digital divide persists

Despite the rapid spread of digital technologies, more than 800 million people lack mobile access worldwide (63 percent of them in the bottom 40 percent of the income distribution), and 4.3 billion lack internet access (49 percent in the bottom 40).[16] For every person connected to the internet in developing countries, almost three are not, and in some countries, 20 are not. Big gaps remain by income, age, location, and gender (figure 2.4). In African countries, the bottom 40 percent is only one-third as likely to have access to the internet as the upper 60 percent;[17] 18 percent of men report using the internet versus 12 percent of women, and 20 percent of youth versus 8 percent of those more than 45 years old. Such demographic gaps persist also in Latin America, and even in high- and middle-income European countries.[18]

The digital divide reflects inequalities in access and barriers to productive use. Many areas simply remain unconnected (chapter 4). Even when a region is connected to the internet, access is not easy. In Cameroon, Ghana, Kenya, and Uganda, more than three in four users still access the internet in commercial internet cafes, where high costs and slow connections limit use.[19] A survey of 25 developing countries found that although commercial cafes were more expensive than telecenters, they had more skilled staff and more reliable infrastructure and service.[20] But this is not the whole story. Illiteracy and lack of skills are important barriers. In a subsidized internet and mobile telephony program in rural Peru, mobile phone ownership increased, on average, by 12 percentage points, but internet use increased by only 2 percentage points.[21] Explaining this gap is the lower internet use among adults than among youth, and the lack of use among the uneducated. Even among the literate, internet use may be limited by a lack of content in local languages.[22]

Figure 2.4 The digital divide within countries remains wide, especially in internet use

Internet use in Africa, by demographic and socioeconomic characteristics, 2011–12

Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_4.

Note: The chart shows a simple average for 12 countries.

Creating jobs, boosting labor productivity, and benefiting consumers

The overall impacts of digital technologies on employment and earnings are positive, if highly heterogeneous (table 2.1). As discussed throughout this chapter, rigorous evidence remains limited, but it suggests that most gains accrue disproportionally to the better educated, with technology complementing the skills and assets of users. But there are exceptions. In Peru, between 2007 and 2009, new internet users had higher income growth than those who remained nonusers, with larger gains in rural areas.[23] And in the United States the diffusion of broadband increased employment rates more in rural areas than in urban.[24]

What explains the aggregate differences? The first factor is the type of technology. Mobile phones can be particularly beneficial to people in more disadvantaged groups—who often lack skills for using the internet, or work in agriculture, where mobile phones alone can pay off. Thus the benefits from mobile phones tend to be widespread. In Peru, for

Table 2.1 Digital technologies affect employment and earnings, the evidence shows

Authors	Country	Technology	Key findings
De los Rios (2010)	Peru	Internet	Internet adoption was associated with labor income gains of between 13 and 19 percent. There was no effect on the probability of finding employment.
Klonner and Nolen (2010)	South Africa (rural)	Mobile phones	Mobile phone coverage increased (wage) employment by 15 percentage points, mostly due to increased employment among women, especially those without significant child care responsibilities. Among men, it induced a shift from agricultural employment to other sectors.
Kolko (2012)	United States	Internet	Broadband expansion was associated with local population and employment growth, but average wages and overall employment rates were unaffected. Localities with broadband became more attractive, and the supply of workers responded to job opportunities.
Marandino and Wunnava (2014)	Uruguay	Laptops and internet	In two years, the One Laptop per Child program had no impact on average households' labor earnings but led to a 33-percent increase in hourly labor income among households below the median income. Richer households already had access to technology before the program.
Ritter and Guerrero (2014)	Peru (rural)	Internet and mobile phones	Access to internet and mobile phones increased wage employment, the production of processed goods, and the prices farmers received for their products. Mobile phones were the main driver for agricultural activity, while internet access was the main driver for employment outside agriculture.

Source: WDR 2016 team.

both mobile and internet use, the better educated benefited most, but while very few of the less educated adopted the internet, they benefited greatly from their new mobile phones.[25] Second is the labor market context. Technology makes a difference when it helps overcome obstacles to employment or higher productivity. In Peru, mobile phones were more beneficial in agriculture, where lack of access to relevant and timely information kept people from accessing better opportunities, whereas internet access made more of a difference outside agriculture, where employers seemed to demand ICT skills and internet use. If the constraints are elsewhere, technology will not make a difference. In rural South Africa, the rollout of mobile phone networks increased employment among women, but only for those who did not have significant family responsibilities.[26]

These aggregate effects of digital technologies on opportunities are mediated through three mechanisms (see figure 2.1):

- *Creating jobs.* Digital technologies promote inclusion by boosting employment and earnings in the ICT sector or in ICT occupations across the economy. But most important, they support jobs and earnings in sectors that use ICT when firms and the self-employed adopt new technologies and grow, as well as through ICT-enabled outsourcing and entrepreneurship.
- *Increasing worker productivity.* By taking on some tasks previously performed by workers, digital technologies augment workers' skills, increasing their productivity and earnings. Digital technologies can also connect people to work and markets and facilitate the accumulation of productive assets. This increases efficiency in the labor market and the overall economy by allowing workers and firms to better leverage existing assets.
- *Benefiting consumers.* When digital technologies automate processes and generate economies of scale, they can lower prices and create new goods and services, thus increasing consumer surplus.

While quantifying these benefits is difficult, the evidence discussed in the rest of the chapter suggests that they accrue most to those already better off (table 2.2). Employment in the ICT sector and in ICT occupations is limited and mostly for high-skilled workers. In industries that use ICT, the potential is greater, especially for those who have skills that better complement the technology. But the largest payoff from digital technologies is increased labor productivity. Better and cheaper information that helps connect people to inputs, outputs, and work is particularly promising for the poor, since it addresses a key barrier to raising incomes for people previously disconnected from markets. The lower communication costs associated with mobile phones, the most common technology for the poor today, can increase the efficiency of agriculture and labor markets, raising household incomes and reducing poverty. As governments and the private sector get better at tailoring digital services to the poor, those gains should increase.

Table 2.2 Benefits of digital technologies for workers and consumers: A scorecard

Channel	Impact so far		Potential impact	
	Poor	Nonpoor	Poor	Nonpoor
Creating jobs				
In the ICT sector and occupations	Negligible	L	Negligible	L
In sectors that use ICT	L	M	L	M
Increasing worker productivity				
Increasing returns to human capital	L	M	L	H
Connecting people to work and markets	M	H	H	H
Benefiting consumers				
Increasing consumer surplus	M	H	H	H

Source: WDR 2016 team.

Note: Poor refers to the bottom 20 percent of the welfare distribution. The differential impact summarizes the discussion in the chapter and is a qualitative assessment of the evidence. ICT = information and communication technology; L = low; M = medium; H = high.

Creating jobs

In ICT sectors and occupations

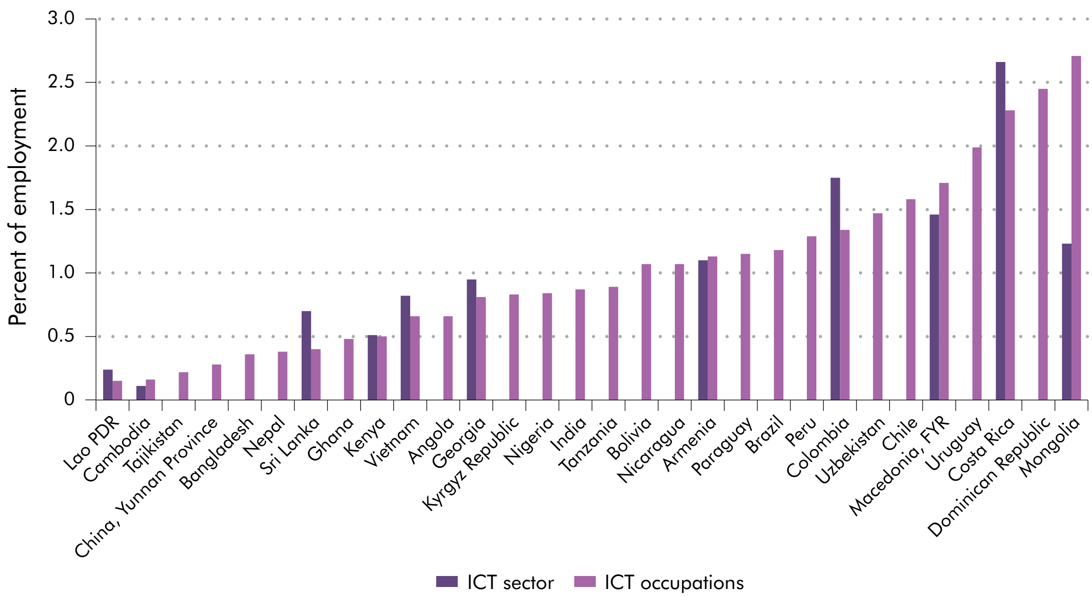
In terms of employment, the ICT sector is small, has high entry barriers, and remains male dominated. The ICT sector employs, on average, 1 percent of the workers in developing countries (figure 2.5). ICT occupations—such as network administrator and electrical and electronic engineer—are also 1 percent of employment in developing countries, and 2–5 percent in member-countries of the Organisation for Economic Co-operation and Development (OECD).[27] Even in the United States, since 2000, new technology-related industries—such as e-commerce and social networking—have accounted for only 0.5 percent of employment.[28] Nor is the sector labor intensive. Instagram, a photo sharing app, had just 13 employees in 2012, when it was bought by Facebook for US$1 billion. Facebook, in turn, had 5,000 employees at the time—compared with 145,000 at Kodak at its peak in photographic film in the 1990s. Yet Facebook's market value is several times what Kodak's was back then.[29] And most of these jobs are high-skilled. In developing countries, on average, half of all workers in the ICT sector have a tertiary education, compared with one-quarter elsewhere. The gender gap is also large, with men 2.7 times more likely than women to work in the sector and 7.6 times more likely to be in ICT occupations.[30]

While not numerous, ICT jobs pay well and can generate additional jobs through consumption and production spillovers. The median hourly earnings in the ICT sector and in ICT occupations are 1.5 times higher than in urban non-ICT sectors or non-ICT occupations in developing countries.[31] The high pay reflects a workforce that is better educated than average. It likely also reflects the relative scarcity of ICT workers in some countries, driving up the skill premium. These high-paying jobs create more demand and new jobs outside ICT. In the United States and Turkey, one job in the high-tech industry generates an average of 3 to 5 additional jobs elsewhere in the local economy.[32] Many of these additional jobs are low-skilled or medium-skilled in such local services as retail, cleaning, and food preparation. Kenya's mobile money service M-Pesa uses more than 80,000 agents or service locations that make an average profit of US$70 a month.[33] Hormuud Telecom—the largest operator in Somalia—employs 5,000 staff but supports 25,000 agents. Given the high skill requirements of the ICT industry, these employment spillovers are more likely to benefit the poor.

Expanding businesses that use ICT

The greatest employment potential of digital technologies lies outside the ICT sector. By improving productivity and boosting firms' growth throughout the economy (chapter 1), digital technologies can increase aggregate employment and earnings. In China, between 1997 and 2007, the increase in internet domains and users per capita had a positive impact on firms' employment in ICT-intensive industries.[34]

Figure 2.5 Employment in the ICT sector and in ICT occupations remains small



Source: WDR 2016 team, based on the Skills Towards Employability and Productivity (STEP) household surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and World Bank); and South Asia Region MicroDatabase (SARMD) (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_5. The STEP surveys used in this Report cover 11 countries: Armenia, Bolivia, Colombia, Georgia, Ghana, Kenya, Lao PDR, FYR Macedonia, Sri Lanka, Ukraine, and Vietnam, as well as China, Yunnan Province.

Note: The ICT (information and communication technology) sector includes ICT manufacturing industries, ICT trade industries, and ICT services (OECD 2011). ICT occupations refer to ICT specialists (OECD 2004, 2014).

In Brazil, between 2009 and 2013, firms in industries intensive in the use of ICTs had higher wage increases across skill levels than the rest of the economy (figure 2.6), although they did not experience faster employment growth. Wage growth was especially high for workers moving across firms.[35]

Recent studies, despite measurement difficulties, find a positive causal effect of firms' technology adoption on employment and earnings, especially in firms with skilled workers who can make the best use of digital technologies. Thanks to a tax allowance program for ICT investments in small firms in the United Kingdom, digital technologies raised labor productivity within firms and increased the demand for workers performing high-skilled tasks.[36] In Norway, a 10-percentage-point increase in broadband availability in a municipality raised wages of skilled workers by about 0.2 percent, while lowering wages for low-skilled workers.[37]

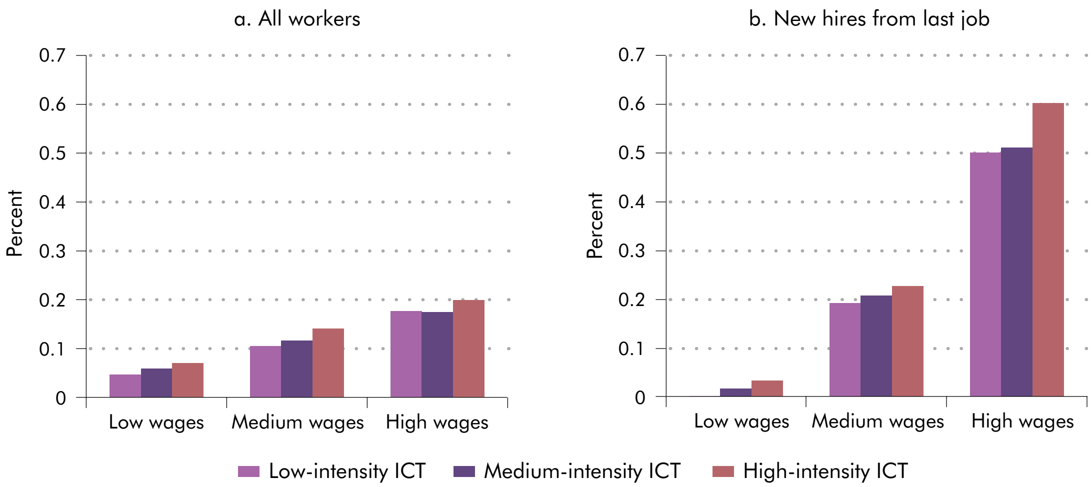
Internet-enabled offshoring and outsourcing, including online work

Internet-enabled offshoring is an important source of jobs in developing countries and for women. An estimated one in four jobs in the United States has already been offshored or could be offshored in the future.[38] These jobs are often in business processing, including call centers and bookkeeping. Such jobs include those that can be broken down into routine tasks but also those requiring high skills and judgment if they can be reliably performed and monitored remotely. Almost half of business process outsourcing (BPO) is in banking and financial services, and another 20 percent is in high-tech and telecommunications. Some tasks of radiologists and other medical services are increasingly also offshored. India, China, the Philippines, and South Africa are the leading BPO hosts.[39] The BPO industry in India employs more than 3.1 million workers, 30 percent of them women.[40] In the Philippines, it employs 2.3 percent of all workers (box 2.1). In rural India, a three-year awareness program on opportunities in the BPO industry increased women's enrollment in relevant training programs, as well as school enrollment among young girls, by 3–5 percentage points.[41]

New technologies are now also challenging the status quo of the outsourcing industry. Many of the characteristics that make jobs "offshorable" also make them more vulnerable to automation. So, as technology improves and wages rise, some of the jobs typically offshored, such as call center jobs, could be automated. Indeed, a local health care company in

Figure 2.6 In Brazil, internet and software use by firms throughout the economy is associated with higher earnings

Average annual wage growth, by firms' ICT intensity and workers' wage levels, 2009–13



Source: Dutz and others 2015, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_6.

Note: The categories of wage levels are terciles. ICT = information and communication technology.

South Africa is already using Watson, IBM's artificial intelligence system, to assist in customer service.[42]

Outsourcing opportunities are increasing in other areas through online work, providing workers and firms with access to larger, even global, employment marketplaces (box 2.2). People can work for any employer anywhere, with parties buying and selling services that can be delivered online. Upwork (formerly Elance-oDesk), the largest online outsourcing service, had 2.8 million job postings worldwide in 2014.[43] Online jobs range from the very simple that can be completed in a few minutes—such as sign-ups, forum participation, review writing, and website testing—to the more complex, such as software development, translation services, data entry, and administrative support. The online work market, though still a tiny fraction of overall employment, is worth around US$1 billion annually, up from US$700 million in 2009.[44]

Impact-outsourcing brings online work to vulnerable communities. Still in its infancy—employing around 150,000 workers, or 3 percent of the total BPO industry—it is taking hold in India, Kenya, and South Africa. The government of Kerala, India, outsources information technology services to cooperatives of women from poor families through the Kudumbashree ("Prosperity of the Family") project. Average earnings were US$45 a month, with close to 80 percent of women earning at least US$1 a day. Nine in ten of the women had previously not worked outside the home.[45] Samasource, RuralShores, and Digital Divide Data are three private service providers. Samasource splits jobs into microwork for almost 6,400 workers, mostly in Ghana, Haiti, India, Kenya, and Uganda, on average more than doubling their previous income.[46]

Online work can prove particularly beneficial for women, youth, older workers, and the disabled, who may prefer the flexibility of working from home or working flexible hours. On freelancer.com—an online outsourcing platform with more than 10,000 microworkers globally—57 percent of workers are between 16 and 25 years of age.[47] In Elance (part of Upwork), 44 percent of workers are women, compared with just 25 percent in the nonagricultural economy (figure 2.7). In a survey on microworkers .com carried out for this Report, 27 percent of workers see being able to work at home and flexible hours as the main advantages of working online. These are the reasons most cited, even more often than earning extra income, especially among women (figure 2.8).

Internet-enabled entrepreneurship and self-employment

By lowering information barriers and costs, the internet increases experimentation and gives rise to new opportunities for entrepreneurship and self-

Box 2.1 Business process outsourcing and jobs in the Philippines: Opportunities and challenges from technological change

The information technology (IT) and business process outsourcing (BPO) industry in the Philippines has been a driver of economic growth and job creation in the last decade. It has grown at an average of 24 percent annually, and its share of the global offshore services market went from 5 percent in 2006 to 11 percent in 2013. Direct employment reached 1 million full-time employees in August 2014 from virtually zero in 1999, accounting for around 2.3 percent of the country's total employment. The industry has a robust voice sector (primarily call centers), accounting for 64 percent of the industry's revenue. Health care information management employment grew by 47 percent from 2012 to 2013. IT outsourcing revenues also grew by 52 percent from 2012 to 2013, while knowledge process outsourcing grew by 18 percent.

Earnings and skill requirements vary across these sectors. Industry-specific jobs tend to be higher skilled than those that cut across industries (such as human resources business processing), as they require more technical knowledge. In 2012, average annual compensation per employee in the industry was around US$8,849, with the highest average compensation in software development (US$17,383). It was US$8,301 for contact centers and US$7,687 for other BPOs. High-skilled, high-paid occupations—as are most research and development–related jobs in knowledge process outsourcing (such as market research and medical transcription), IT outsourcing (such as software and application maintenance), engineering services (such as engineering design and digital mapping), and creative processes (such as art production and game testing and support)—are intensive in nonroutine cognitive and interpersonal tasks. Middle-skilled occupations are intensive in routine cognitive tasks, mostly in nonvoice BPO (such as back-office finance and accounting or human resources), but can also include many of the jobs in voice business processing (such as customer service and technical support).

Progress in digital technologies and international competition increases the need to move to more high-value-added, nonroutine jobs. In the Philippine IT-BPO industry, 85 percent of the revenues are generated in jobs intensive in routine cognitive tasks, with workers increasingly susceptible to automation. Low wages will delay this process but are unlikely to halt it. As the global market for complex services grows, providing a larger volume of high-value nonvoice services can promote the industry's sustainability. This transition requires a concerted effort among business, academia, and government to make systemic improvements across the IT-BPO ecosystem, such as enhancing telecommunications infrastructure and directing industry-government partnerships toward more nonvoice training and skills development.

Source: WDR 2016 team, based on Capili 2015, for the WDR 2016.

employment (box 2.3). Many are in the ICT sector, but others are ICT-enabled (see also chapters 1 and 4). Alibaba in China, the world's largest e-commerce platform by sales volume, supports an estimated 10 million jobs, or 1.3 percent of China's workforce. Online shop owners using Alibaba in China, on average, employ 2.6 additional workers. Four in ten shop owners are women, 19 percent were previously unemployed, 7 percent were farmers, and about 1 percent are persons with disabilities. Alibaba is estimated to support an additional 2 million jobs, most in logistics.[48] In Morocco, home-based female weavers sell rugs and other textiles over the internet to keep a larger share of their profits.[49] Etsy, a peer-to-peer e-commerce platform focused on handmade or vintage items, and similar services, can take this to scale. Etsy has 20 million active buyers and 1.5 million active sellers worldwide, with 31 percent of its sales outside the United States.[50]

As online commerce, the on-demand or sharing economy—in which people rent assets or command services directly from one another, coordinated through the internet—is growing rapidly, if still small overall and just emerging in developing countries. More than two-thirds of internet users globally are willing to be part of the sharing economy.[51] In Uganda, food delivery services online are used by the diaspora to send in-kind remittances to family members. In Kenya, Sendy connects customers with motorcycle couriers for delivery services, which can then be paid with mobile money. As of March 2015, Airbnb—the largest site for peer-to-peer accommodation—reported operating in more than 34,000 cities and 190 countries, with more than 25 million guests.[52] Peer-to-

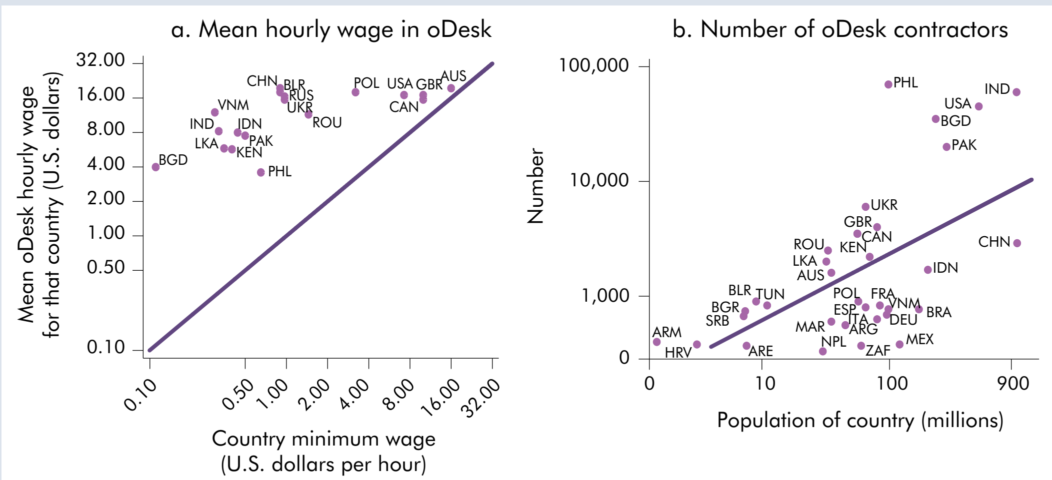
Box 2.2 The economics of online outsourcing

Online outsourcing or freelancing platforms match firms and workers to perform work online. They can reduce contracting costs and the time it takes to match employers and employees. Through Upwork, the largest of these platforms, the time it takes to hire a worker can fall from 43 to 3 days.[a] On the workers' side, around 45 percent of freelancers on Upwork earn most or all of their income through online work. In oDesk—with Elance, one of the two original platforms behind Upwork—hourly earnings are on average 14 times higher than minimum wages in developing countries (figure B2.2.1, panel a). This is partly explained by the fact that online workers are better educated than those in the general economy. High-paying work is concentrated in information and communication technology (ICT) areas such as software development, which can pay twice as much as online work in writing and translation, and even three to four times more than that in customer support and sales.[b]

Thanks to the internet and innovations in monitoring and feedback systems, online labor markets are becoming global. Online job platforms increase the pool of talent for firms, especially for smaller enterprises, and provide an opportunity to monetize skills that may not be in sufficient demand in the local economy. An individual in Mongolia with expertise in web development and a programming language such as Python can make close to US$40 an hour online. On Upwork, 90 percent of the work is offshored. On the largest platforms, most employers are located in developed countries and most workers in developing countries. Australia, Canada, and the United States are the largest employers. On oDesk, Bangladesh, India, Pakistan, the Philippines, and the United States have the largest number of contractors in relation to their populations (figure B2.2.1, panel b).

Yet the internet only partly overcomes labor market segmentation, and some barriers to inclusion and to further expansion of online labor markets remain. On Upwork, a given worker is 1.3 times more likely to find work in her domestic market, and domestic contractors get paid more than international contractors for the same type of work.[c] Online outsourcing is most likely to function like a truly global market when tasks are less complex and involve fewer local institutions and less communications. Additional constraints that could be addressed by policy are related to language (mainly English), regulations, payment platforms, and trust.[d]

Figure B2.2.1 Online labor markets provide work and fairly good pay for workers in developing countries



Source: Agrawal and others 2013.

Note: oDesk is now part of Upwork, together with Elance. In panel a, the line inside the figure is the 45-degree line along which hourly wages in oDesk are the same as the country's minimum wage; in panel b, it is a regression line. In panel b, the number of contractors refers to those who have ever worked on oDesk.

a. http://elance-odesk.com/online-work-report-global, accessed March 26, 2015.
b. Agrawal and others 2013.
c. Lehdonvirta and others 2014.
d. Kuek and others, forthcoming.

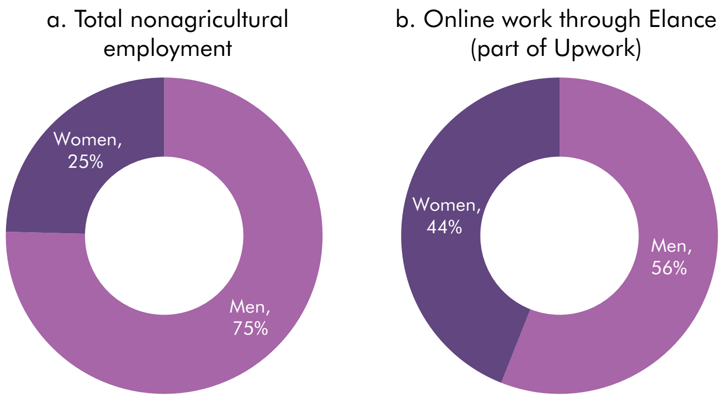
peer car services such as Uber, which operates internationally, or Didi Kuaidi in China, are growing fast. Expanding the principles of the on-demand economy to the urban self-employed in developing countries could be particularly promising. These workers often lack references and documented work histories when seeking jobs and depend on word of mouth to expand their customer base. In this setting, the sharing economy's decentralized, crowd-based rating systems can help control quality, build trust, and maintain a live "resume." Plumbers and handymen can expand their client pool by building strong reputations online.

These new jobs in the sharing economy have advantages for workers, but they also come with trade-offs. The main advantages for workers are supplemental income and flexibility. In the United States, 61 percent of sharing economy participants say earning extra money is their main motive.[53] Workers appear to sort into a working arrangement that suits their preferences and family circumstances. Two-thirds of Uber drivers in the United States vary their hours

Figure 2.7 Online work expands women's access to work

Global nonagricultural employment composition by gender, "offline" and online

percent of total employment

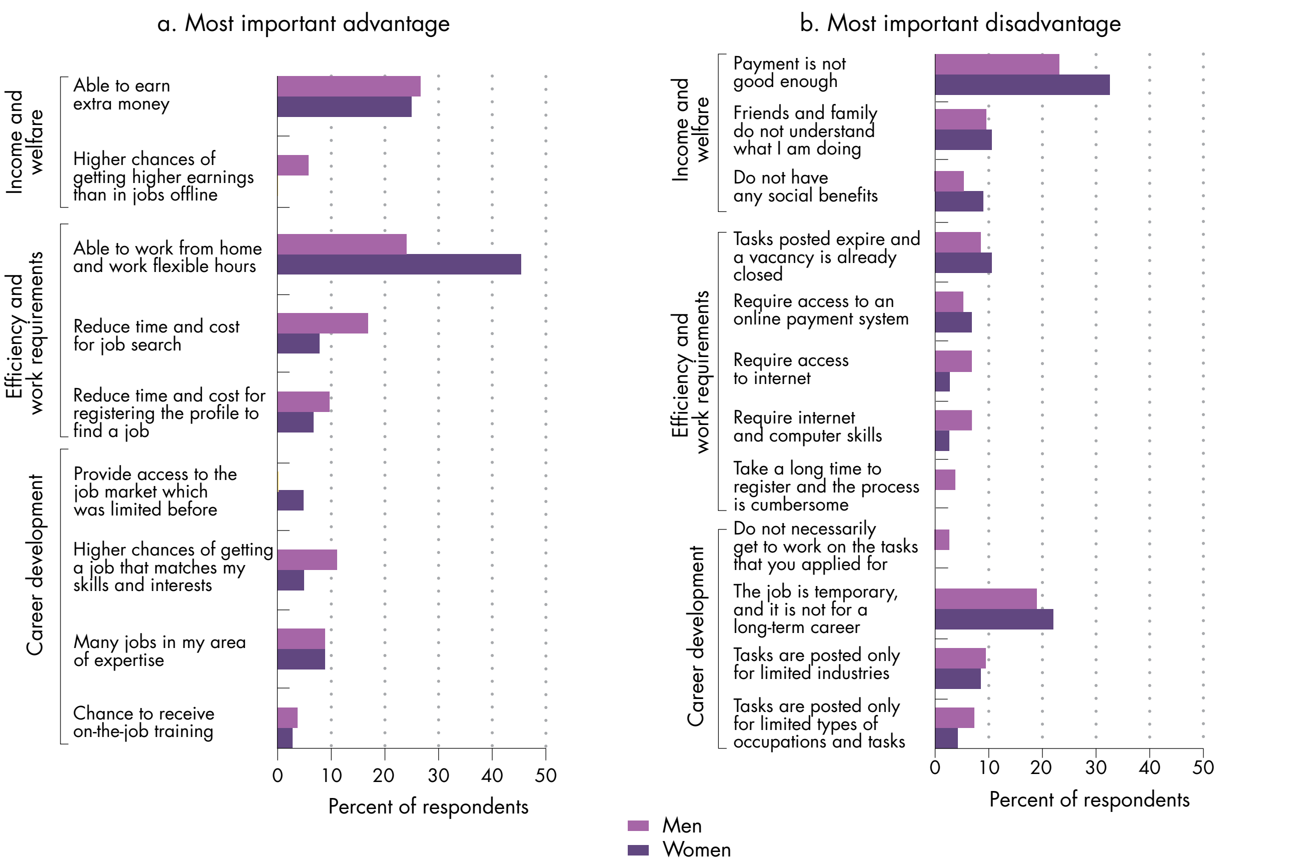


Sources: WDR 2016 team, based on World Development Indicators (World Bank, various years) and Elance Annual Impact Report "Work Differently," June 2013. Data at http://bit.do/WDR2016-Fig2_7.

Note: Results are population-weighted. China is not included. For panel a, latest available data between 2008 and 2013.

Figure 2.8 Flexibility in hours worked and the ability to work from home are the main advantages of online work, but relatively poor pay and lack of career prospects are concerns

Microworkers.com: Most important advantage (panel a) and disadvantage (panel b) of using an online work platform over a traditional job "offline"



Source: Survey of online workers at microworkers.com, where the majority of workers are from developing countries, especially South Asia. Based on Imaizumi and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_8.

Box 2.3 Expanding opportunities through online music

Usman Riaz began piano lessons at age six in his native Pakistan. He later wanted to explore new instruments and musical styles, but he could not find the right teachers in his own country. Instead, watching videos online, he taught himself percussive guitar, a style that uses the strings and the instrument's body for percussive effects. Riaz also used the internet to showcase his music. His song "Fire Fly" went viral in 2011. A year later, he shared a stage in Edinburgh with Preston Reed, one of his online idols.

The internet has exposed people around the world to new cultural influences—not just global pop culture hits, but also in the tiniest niches. Whether it has also helped many more artists in developing countries gain access to arts and entertainment markets is difficult to say, given the lack of suitable data. Globally in 2014, revenues for recorded music were about US$15 billion and falling, compared with US$25 billion for live performances, whose revenues are rising.[a] Pirating, YouTube, and music streaming have led to an overall decline of music sales in developed and developing markets. Most of the revenue goes to the biggest stars: the top 1 percent of artists earn about 80 percent of recorded music revenue.[b] At the same time, file sharing has raised the demand for concerts,[c] which has always been the biggest source of income for most musicians.[d] As the cost of recording and distributing music has gone down, online music sharing could become an effective advertising vehicle for musicians in developing countries—although limited internet access and slow speeds make this harder. Even if only a small minority break into national or even international entertainment markets, the welfare benefits of being able to learn from others and share talents on the internet can still be significant.

Source: Kabanda 2015, for the WDR 2016.

a. PricewaterhouseCoopers 2015.
b. Thompson 2015.
c. Holland, Nosko, and Sorensen 2012.
d. Connolly and Krueger 2006.

worked by more than 25 percent from week to week. This flexibility is likely to be valuable for women and youth and for people between jobs. But these benefits come at a possible cost since these jobs do not provide much work security or protection to workers.[54]

Increasing worker productivity

Increasing returns to human capital

Digital technologies can complement human capital, allowing workers to focus their efforts on activities with higher value and making them more productive. Farmers can use precision agriculture or track livestock. Teachers can use massive open online courses (known as MOOCs) or online teaching tools like Khan Academy, better using study time inside and outside the classroom to increase practice and discussion, and dedicating more time to children who fall behind. Researchers can dedicate more time to thinking and innovating rather than spending time searching for information or duplicating other people's work. Managers can work more easily with teams across borders.

In fact, there has never been a better time to be a well-educated worker. Chapter 1 shows how digital technologies increase labor productivity within firms. Workers who are able to work with digital technologies and complement them are well positioned to access more (and more rewarding) employment and higher wages. Returns to education have fallen only in Latin America. Everywhere, average private returns remain high—at 10 percent per year—despite large increases in the supply of educated workers in the last few decades. Returns to tertiary education are the highest, at 14.6 percent; tertiary education is the only educational level for which returns have not fallen since the early to mid-1990s.[55] That reflects strong demand for advanced skills, especially among women (figure 2.9). Returns to education are higher and have been rising more rapidly in ICT-intensive occupations compared to the rest of the economy (figure 2.10).

Connecting people to work and markets

Digital technologies help overcome barriers to productive employment and connect workers and entrepreneurs to (global) markets, clients, and suppliers. This is particularly important for the disadvantaged or often-excluded groups such as the poor, women, minorities, the disabled, and people in remote regions (box 2.4). For all of them, high search costs, long distances, and a lack of information are key obstacles.

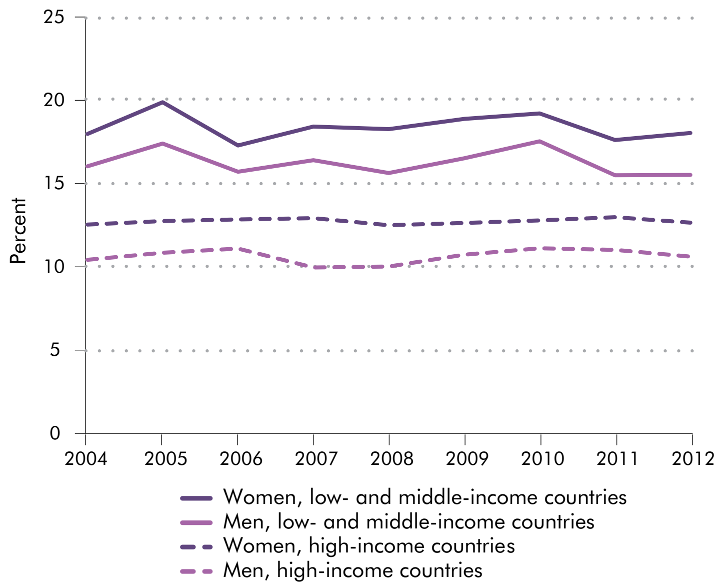
The internet makes labor markets more efficient by connecting a larger pool of individuals and firms at lower cost.[56] Indeed.com, Monster.com, and elempleo .com are international platforms that aggregate job vacancies from different sources and allow firms to post job openings, and workers to apply for jobs and post résumés. Similar services exist for local markets, such as aldaba.com in the Dominican Republic and kariyer.net in Turkey. Social and professional networking sites also provide information on potential workers, often on behavioral aspects and social ties not reflected in traditional resumes. LinkedIn, the largest online professional network, has more than 310 million registered members, 67 percent outside the United States. In Brazil, LinkedIn's penetration rate is already at 8 percent.[57] In most countries, online job search remains concentrated among youth and the best educated and grows with income: online job search among the employed and unemployed is above 20 percent in urban Armenia and Georgia, but below 5 percent in urban Bolivia, Ghana, the Lao People's Democratic Republic, Sri Lanka, and Vietnam.[58]

Online job boards, social media, and matching platforms can improve labor market efficiency, especially in developing countries and in the informal sector, where information failures are large. Online job matching is cheaper and faster than traditional methods.[59] In Peru, integrating mobile phones into traditional public intermediation services increased employment among job seekers by 8 percentage points in the short term.[60] In Germany, online job seekers are better matched to jobs, are happier with work, and have higher chances of promotion and job security.[61] But other studies find no effect of online tools on the speed of matching or on the length of unemployment.[62] The large number of applications per vacancy and stale resumes and job posts makes it costly for employers to select workers and for workers to find available jobs. As online tools become more advanced, however, matching is becoming more effective. In the United States, the average unemployment duration for internet searchers was 25 percent shorter than for noninternet searchers, reversing earlier results.[63]

Online tools can address many labor market frictions, but much of this potential remains unrealized. A first challenge is reaching lower-skilled workers. Some services, such as Souktel, are solving this via mobile phone (box 2.5). Babajob in India and Duma in Kenya have also implemented innovations to reach the bottom of the pyramid. They use text messaging and "missed calls" to connect low-skilled and informal workers to vacancies. A second challenge is

Figure 2.9 Returns to education remain high despite significant expansion in the supply of educated workers, especially for tertiary education

Average return to one additional year of education in tertiary education

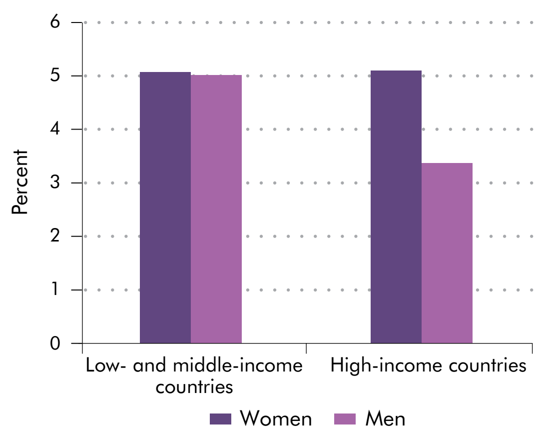


Source: WDR 2016 team, based on Montenegro and Patrinos 2014. Data at http://bit.do /WDR2016-Fig2_9.

Note: Includes 97 countries and only wage employees. The regressions control for potential experience and potential experience squared using individuals' age.

Figure 2.10 Returns to education are particularly high in ICT-intensive occupations

Wage premium, beyond returns to education, for working in an ICT-intensive occupation



Source: WDR 2016 team, based on Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_10.

Note: An ICT-intensive occupation scores 4 or higher in an index between 0 (no use of technology at work) and 6 (most use of technology at work). ICT = information and communication technology.

Box 2.4 Bridging the disability divide through digital technologies

For most people, technology makes things easier. For people with disabilities, it makes things possible.

—Mary Pat Radabaugh, formerly with the IBM National Support Center for Persons with Disabilities

Prakash lost his sight at birth. Today he is a successful entrepreneur and programmer running his own information technology (IT) company in a mid-size city in India. Screen-reading and voice-recognition software enable him to use a computer and write computing programs, and the internet helps him find and connect with clients. Technology augments his business and his life.

Around the world, more than 1 billion people have disabilities, 80 percent of them in developing countries. They face infrastructure and environmental barriers to social, financial, and civic participation, which digital technologies can help overcome. Technology enables multiple means of communication—voice, text, and gestures—to access information and engage with others. Magnification, voice recognition, and text-to-speech benefit persons with visual, cognitive, learning, and mobility disabilities. Short message service (SMS), instant messaging, telephone relay, and video captions reduce communication barriers for those with hearing and speech disabilities. Hands-free navigation and gesture-controlled interfaces help those with severe mobility impairments.

But if not designed to be accessible, digital technologies can widen the disparities between persons with and without disabilities. Free and low-cost mobile apps offer increased functionality for persons across the disability spectrum. Assistive software is available for feature phones. Accessibility enhancements for web browsers promote greater internet use by persons with disabilities. Governments should focus on building the capacity of public bureaucracies, teachers, vocational trainers, employers, and information and communication technology (ICT) professionals to design accessible content and support ICTs for persons with disabilities; developing the legal, policy, and regulatory foundation for accessible ICT; supporting, through public-private partnerships, the development of accessible ICT, such as local language text-to-speech and voice-recognition software; and mainstreaming accessibility in all public services offered through ICT, such as disaster warnings and communications, public services, and financial services.

Source: Raja 2015, for the WDR 2016.

providing supporting services. There is high demand for supporting services in online work, especially from women. In Souktel, 40 percent of women and 30 percent of men report a need for career coaching.[64] A third challenge is receiving up-to-date vacancy information, since many postings are stale. Employers also report a fairly high rate of no-shows for interviews. A two-side rating system—quality control on vacancies' expiration dates, and short message service (SMS) reminders to candidates selected for interviews—can address some of these shortcomings.

Making work more flexible

Digital technologies can bring women and new entrants into the labor market, especially in white-collar occupations, by allowing people to work on different schedules or from different locations. In Georgia, Romania, and Ukraine, more than 10 percent of employment is part-time, up from less than 5 percent a decade earlier.[65] Video conferences and e-mail make it easier to work away from an office. In the European Union, telework doubled to reach 9 percent in the first half of the 2000s, and around 23 percent of enterprises in the EU-15 employed teleworkers in 2006, up from 16 percent in 2003 and 18 percent in 2004. In the United States, in 2009, one-quarter of workers used telework regularly.[66]

The rise in telework has been particularly rapid among female workers in Europe.[67] Budget airlines, such as JetBlue, manage their customer support centers largely with home workers, mostly women.[68] Telework can also make it easier for youth to combine school and work and for older workers to work longer. These new work arrangements can address skill gaps and increase productivity. Facilitated by the internet, home-based work in a 16,000-employee travel agency in China improved worker productivity by 13 percent.[69] And where there is a shortage of doctors, telemedicine and examinations of digital X-rays can be very helpful. In Uruguay, through teleconferencing,

Box 2.5 Using digital technologies to match workers with jobs: Souktel in West Bank and Gaza

Souktel is an online job-matching service started in 2009 and operating primarily in West Bank and Gaza, but also active in the Arab Republic of Egypt, Jordan, Morocco, Rwanda, and Somalia. There are more than 15,000 registered job seekers. The service registers job seekers through short message service (SMS) and online, provides information on vacancies, advises on resume preparation, and does active job matching by screening potential candidates for vacancies. Notifications on relevant job vacancies are sent through voice calls and SMS once or twice a week. Job seekers in the platform are young (80 percent are age 15–25) and well educated (all have completed secondary and half have completed tertiary education). Among Souktel's core users, 4 of 10 do not have jobs. Women are 30 percent of all online job seekers in Souktel, a share that is 15 percentage points higher than at the national level (figure B2.5.1, panel a). There are 200 registered employers, 80 percent of which are medium in size.

The main benefit that job seekers see in Souktel's service is saving time and money. Most workers look for jobs that match their skills and experiences, but more than one-third look for jobs in new occupations or industries. Souktel connects users to better-paying jobs. The share of workers earning less than the overall average monthly earnings (around US$500 per month) drops both for men and women after finding a job through Souktel (figure B2.5.1, panel b). About 70 percent of users have been invited for a job interview at least once. Employers report that using online job platforms allows them to hire from a prescreened pool of high-quality candidates and reduces the time and cost for hiring. Firms report a reduction in recruiting costs of about 20 percent.

Figure B2.5.1 Online platforms improve female labor force participation and access to higher-paying jobs

Source: Imaizumi and Santos, forthcoming, for the WDR 2016. Data at http://bit.do/WDR2016-FigB2_5_1.

English is being taught to first graders by teachers from the Philippines, raising the children's English scores and the English proficiency of Uruguayan teachers.[70]

Improving access to markets and productive inputs

Digital technologies, especially the internet, make it easier for people to sell products in new markets. E-commerce platforms are one example. In Uganda, wider mobile phone coverage induced market participation of farmers in remote areas, especially among those producing perishable crops.[71] In India, e-Choupal has provided computers and internet access in rural areas. Farmers can place orders for inputs, and directly negotiate the sale of their produce with buyers. With 6,500 kiosks, it now reaches 4 million farmers in more than 40,000 villages.[72]

Digital technologies can increase access to more productive assets and better quality services, raising

Box 2.6 The impact of digital technologies on remittances

Online and mobile money transfer systems offer new cost-effective means of sending money. In Kenya, among the 53 percent of adults who reported having sent remittances in the past year, 90 percent did so using a mobile phone.[a] Today, the average cost of sending money is 8 percent of the remitted value. Mobile technology can lower this cost by removing the need for the physical presence of staff and customers, while ensuring timely and secure transactions.

Digital technologies make domestic and international remittances cheaper. In Kenya, in 2008 shortly after M-Pesa entered the market, the cost of sending US$100 domestically was US$12 by MoneyGram, US$20 by bank wire, US$6 by postal money order, and US$3 by bus, compared to US$2.50 by M-Pesa. In Cameroon, costs have declined by 20 percent since mobile money entered the market. Prices have also fallen for international remittances. In the United Kingdom-Bangladesh corridor, the cost of sending US$200 through Western Union fell from 12 percent in 2008 to 7 percent in 2014 after the entry of digital competition. Between the United States and Mexico, Xoom charges 4.4 percent for online money transfers, down from Western Union's 6.2 percent. But the costs are still high for the poor, since they make many small transactions, which tend to be more expensive—more than 5 percent for amounts less than US$5.

Across the board, traditional remittance service providers are building their own mobile and online capabilities, but international digital remittance services have yet to take off in a substantial way. As of early 2012, only 20 percent of 130 mobile banking operators worldwide offered such services. The value of international remittances through mobile phones accounted for less than 2 percent of global remittances in 2013.

Policy action is called for on several fronts. First is fostering innovative cross-border mobile money transfer technologies. That requires harmonizing banking and telecommunications regulations to enable banks to participate in mobile money transfers, mobile companies to offer mobile money services without exclusivity agreements, and telecommunications firms to offer micro-deposit and savings accounts. It also requires simplifying regulations aimed at stopping money laundering and the financing of terrorism for small-value transfers. And it requires ensuring that mobile distribution networks are open to multiple international remittance service providers.

Second is increasing competition by eliminating telecom monopolies and exclusivity contracts. The experience in the United States-Mexico corridor shows how eliminating an exclusivity agreement between Western Union and Elektra can reduce prices. The interoperability of money transfer operators in remittance markets, as in Indonesia, Pakistan, Sri Lanka, and Tanzania, can reduce prices further.

Source: Plaza, Yousefi, and Ratha 2015, for the WDR 2016.

a. Demirgüç-Kunt and others 2015.

an individual's long-term productive capacity. They can help build human capital throughout the life cycle, managing risks and increasing access to financial capital and remittances (sector focus 2; spotlight 2; box 2.6). Since the poor are often most constrained by these factors, they stand to benefit the most.

Mobile money accounts can drive financial inclusion. In Sub-Saharan Africa, 12 percent of adults have mobile money accounts, compared with just 2 percent worldwide, and 45 percent of them have only a mobile money account.[73] In Kenya, access to mobile money has helped in managing risk. Statistically comparable households that were not connected to M-Pesa, the mobile money service, experienced on average a 6–10 percent reduction in consumption in response to similar shocks.[74] And biometric tools that reduce the costs of identifying borrowers can improve access to financial and other services at the bottom of the pyramid.[75]

Through social and professional networking sites and better connections with friends and family, the internet also enlarges, deepens, and leverages social capital to find jobs and access resources (spotlight 3).[76] In the United States, internet users have a larger extended network activated when looking for a job.[77] Digital technologies can also increase agency and modify aspirations, affecting social norms that can be barriers to participation, employment, and productivity, especially for women,[78] much the same as with soap operas in Brazil and cable television in India.[79] In Africa, the internet appears to broaden social interactions with groups with different political views or religious beliefs.[80] The internet and mobile phones also increase ties between migrants and those remaining in the home country.[81]

Improving access to information

For the poor—who rely on mobile phones and often did not have access to a fixed line—the biggest gains from digital technologies are likely to come from lower information and search costs. When making agriculture and labor market decisions, individuals often rely on informal sources, such as family and neighbors, or are left with no information: six in ten farmers in Boyaca, Colombia, do not know the prices in the capital city.[82] Information technologies can inform workers about prices, inputs, or new technologies more quickly and cheaply, reducing friction and uncertainty, eliminating costly journeys, and reducing the risks of accidents and crime.[83] In rural Niger, mobile phones reduced search costs by 50 percent.[84] In turn, these benefits can reduce poverty. In rural Peru, mobile phones increased household real consumption by 11 percent between 2004 and 2009 and reduced poverty by 8 percentage points.[85] Mobile phones have also been found to reduce poverty in East Africa.[86]

Using technology for getting information on prices, weather, soil quality, and new technologies, and for coordinating with traders is becoming more common in agriculture (sector focus 1). Among fishermen in the Indian state of Kerala, price information on mobile phones increased their profits 8 percent.[87] In Honduras, farmers who got market price information via SMS reported an increase of 12.5 percent in prices received.[88] In Argentina, the TRAZ.AR program to track animals increased profits per kilo of meat by 8 percent.[89] In Pakistan, thanks to mobile phones, farmers shifted to more perishable but higher return cash crops, reducing postharvest losses from the most perishable crops by 21–35 percent.[90]

Digital technologies make the largest difference when learning about information in distant markets or among disadvantaged farmers who face more information constraints.[91] An adult education program on using simple mobile phones in Niger increased internal labor migration and communication with migrants on labor market conditions in faraway regions.[92] Gains and uses are more common when the information transmitted is simple (as with prices or weather) rather than nuanced or difficult to convey (as in agricultural extension).[93] Similarly, when information provided through technology is not relevant to local needs or when there are other constraints to economic activity—such as physical infrastructure or market structure—there are fewer or no gains, as in cases in Ethiopia and Nigeria.[94]

Benefiting consumers

My life became easy after I started using the internet. We can learn about any subject. It also helped me earn some income online by using freelancer sites. It helps me to find health and beauty tips, to know current events and news. Through internet, I am able to stay connected with my friends and relatives.

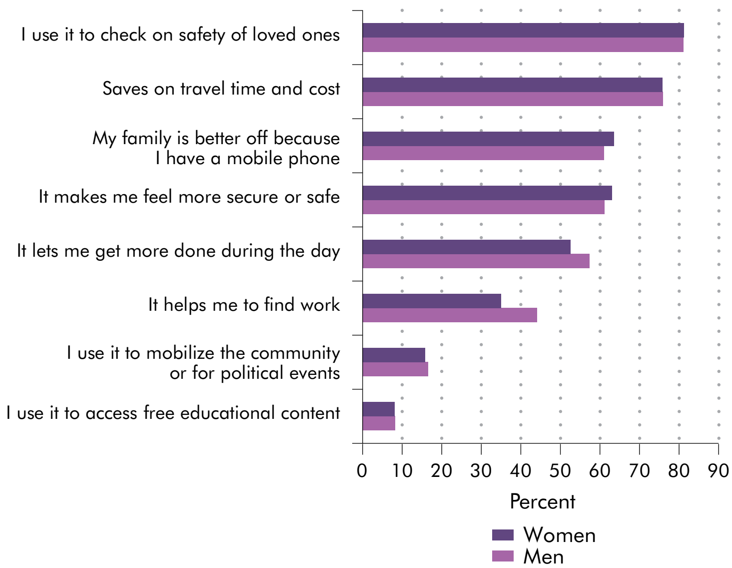
—Young woman, microworker in Amazon Mechanical Turk, September 2014[95]

Beyond earning opportunities, the internet offers many benefits to individuals as consumers, such as consumer convenience, expanded choice, better quality leisure time, and access to more knowledge. These benefits are consumer surplus, often not captured in GDP statistics (chapter 1).

Digital technologies have thus enhanced welfare. Across 12 countries in Africa, 62 percent of people believe that their family is better off because of mobile phones, whereas only 21 percent disagree (17 percent are not sure). And 76 percent of people say mobile phones help save on travel time and costs. A majority (62 percent) also believe that mobile phones make them more secure (figure 2.11). The annual consumer surplus from Google search has been estimated at

Figure 2.11 Mobile phones improve sense of security and save time

Africa: Respondents that agree with each statement on benefits and use of mobile phones, 2011–12



Source: WDR 2016 team, based on Research ICT Africa surveys (various years). Data at http://bit.do/WDR2016-Fig2_11.

US$500 per user, or US$150 billion for the 300 million users.[96] In Estonia, digital signatures saved 20 minutes per signature.[97] In Europe and the United States, consumers are willing to pay an average of US$50 a month for services that they now get for free on the internet.[98] Large consumer surpluses have also been estimated for Brazil, China, and Mexico.[99]

The rapid adoption of digital technologies, despite the costs, speaks for itself. In developing countries, 5 percent of consumption goes into ICT, ranging from 2.8 percent in the poorest households to 6.6 percent in the richest. In Africa, in addition to covering the cost of the hardware, the median phone owner spends more than 6 percent of his or her monthly income on mobile phones for calls and SMSs. The share is over 13 percent when accounting for people who own a mobile phone but do not work (mostly youth and spouses).[100]

Benefits to consumers, while significant, also come with risks. There are concerns about loss of privacy (chapter 4); information overload, as more and more information—some relevant and some not—is at our fingertips; and "overconnectivity," since people are constantly online and reachable. The line between leisure and work is blurring. Digital technologies make leisure time more enjoyable and less costly, but also make workers more productive and allow them to work away from the office. More than one-third of internet users in the United States report working longer hours because of technology, despite also feeling more productive.[101]

Labor market polarization can lead to greater inequality

For workers, digital technologies generate new opportunities for employment and earnings, but also risks. One major risk is related to the speed of labor market changes and the destruction of jobs. Nonstandard forms of work and shorter job tenures are likely to become more common, especially among youth. Internet access has been associated with more job-to-job flows, within the same firm and across employers.[102] Large-scale automation can also accelerate job destruction, especially in developed countries. In addition to factory automation, there is automation of logistics and processing, digitization (data entry, publishing/printing), and self-service (document creation and management versus clerical support, or retail self-checkout).[103]

These changes are good for aggregate productivity, as discussed in chapter 1, but can create challenges for individuals in the transition to new jobs. This is especially the case when the skill needs of new jobs are different from those of the old jobs. Beyond skill-upgrading, the challenge is to ensure that labor regulations facilitate and do not impede these transitions, and that social protection systems support workers when they are between jobs or not working regularly.

A second risk relates to the changing nature of work and the quality of internet-enabled jobs, such as microwork or jobs in the on-demand economy. These new forms of work provide workers and firms with flexibility and improve efficiency in the use of resources, but also come with a possible erosion of workers' bargaining power and a lack of benefits, such as unemployment and health insurance or severance pay. In most cases, workers are considered independent contractors rather than employees. In a world where a job in a firm has been a pathway out of poverty because firms help share risks and provide capital, training, and technology,[104] higher nonwage employment and this "new informality" may not be desirable.

In developing countries, most work does not have these benefits, but especially in advanced countries, a balance is needed between efficiency and protection to avoid a "race to the bottom" in terms of workers' protections. Already, some microwork platforms and companies in the sharing economy provide insurance to workers and collect taxes, but these new developments in the labor market raise questions about traditional approaches for protecting workers. As discussed in chapter 5, this will probably require reforms not only in the new industries but also in the traditional ones to ensure that all workers—irrespective of their type of work contract—have basic protections.

Perhaps the biggest risk from technological change, however, is that of widening income inequality. Although technologies are becoming widespread, the economic payoffs are not. The poor almost exclusively use only mobile phones not connected to the internet. And even if they had access to the internet, they lack the skills to use it productively, with many still unable to read in the first place. Positive impacts from using digital technologies—as with other technologies in the past century—are most likely to be captured by those already better off. In the United States, the adoption of advanced internet applications by firms led to substantial wage growth in the 6 percent of counties that were the wealthiest, the most educated, and had an IT-intensive industry, with no effect elsewhere. Technology explains more than half the difference in wage growth between already well-off counties and others.[105]

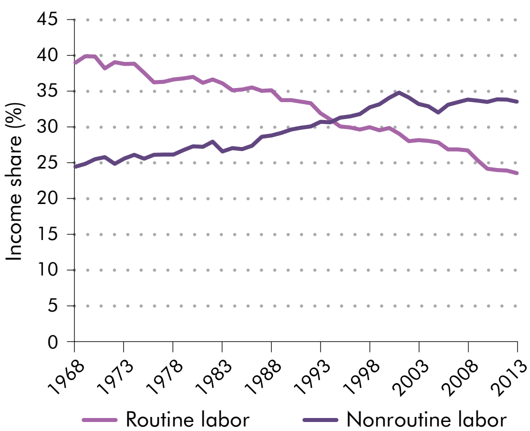
The risk of rising inequality is evident in the declining shares of (routine) labor in national income, and the "polarization" of the labor market—that is, the declining employment in middle-skilled occupations relative to those in low- and high-skilled ones, and the heightened competition for low-skilled jobs. The concern is that the ladder to the middle class is pulled away as middle-skilled jobs disappear or are fundamentally transformed by digital technologies.

Declining shares of labor in national income

Various factors, including technology, are shifting the distribution of income within countries away from routine labor and toward nonroutine labor and capital.[106] In the past few decades, and especially after 2000, the share of national income going to workers has fallen steadily in developed and many developing countries, driven by a falling share of income going to workers performing mostly routine tasks that follow exact, well-defined procedures that can be easily automated (figures 2.12 and 2.13). In the United States, at the technological frontier, the share of income going to routine labor has fallen from 38 to 23 percent since the late 1960s, with a simultaneous rise in the nonroutine labor share from 24 to 34 percent. In Honduras and Romania, in the 2000s, the income share of nonroutine labor increased from 28 to 32 and from 21 to 25 percent, respectively, with declines in the share of routine labor.[107] Where the labor share has fallen most, inequality has risen most (figure 2.14). A growing literature also links recent technological change to widening inequality.[108]

Figure 2.12 United States: Labor share in national income is falling, driven by routine labor

Share of routine and nonroutine labor in total income

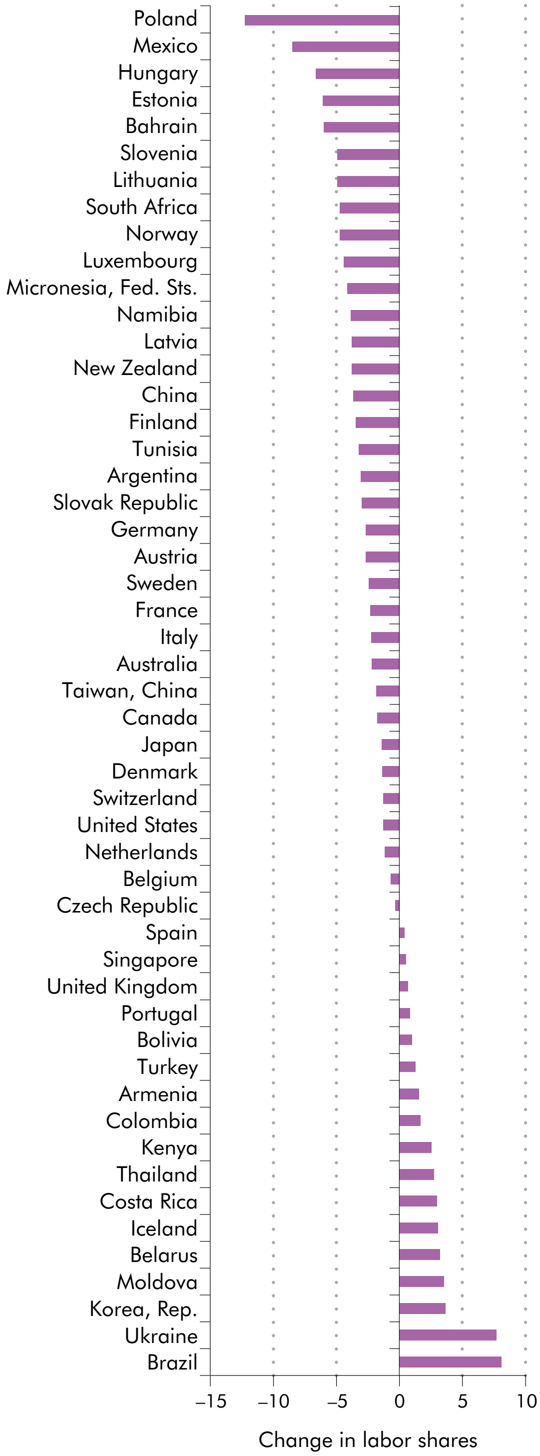


Source: Eden and Gaggl 2014, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_12.

Figure 2.13 Labor shares in national income are falling in many countries, including some developing countries

Trends in labor shares in output since 1975

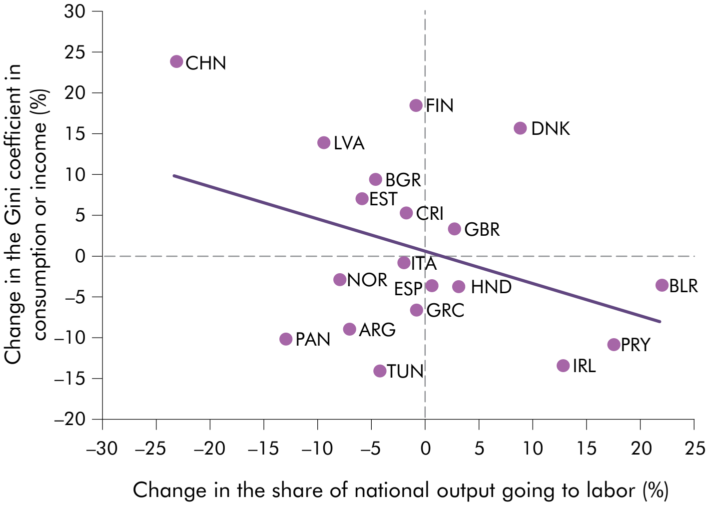
percentage points every 10 years



Source: Karabarbounis and Neiman 2013. Data at http://bit.do/WDR2016-Fig2_13.

Figure 2.14 Falling labor shares in national income are associated with rising inequality

Growth in Gini coefficient vs. growth in labor share in national income, 1995–2010



Source: Eden and Gaggl 2015, for the WDR 2016. Data at http://bit.do/WDR2016-Fig2_14.

Employment polarization

Declining labor shares coincide with the polarization of labor markets, most notably in high-income countries.[109] Employment is growing in high-skilled, high-paying occupations (managers, professionals, technicians) and low-skilled, low-paying occupations (elementary, service, and sales workers). Middle-skilled, middle-paying occupations (clerks, plant and machine operators) are being squeezed (figure 2.15). In high-income countries, on average, the share of routine labor in employment has fallen by about 0.59 percentage points a year since 1995, or almost 12 percentage points for the period. In the United States, local labor markets susceptible to automation due to specialization in routine task-intensive occupations have no net decline in employment, but they experience polarization in manufacturing and services.[110]

There are signs that employment is also polarizing in a number of low- and middle-income countries. The average decline in the share of routine employment has been 0.39 percentage points a year, or 7.8 percentage points for the period. China is an exception, since the mechanization of agriculture increased the share of routine employment.[111] Labor markets in low-income countries such as Ethiopia, with a large share of employment in manual occupations, are also not polarizing; neither is employment in Mongolia or Latin American countries where other factors—such as a commodity-driven boom benefiting low-skilled workers—could play a larger role in shaping labor markets.[112]

Yet declining labor shares in income and job polarization are only symptoms. At their heart is the fact that digital technologies complement and augment some skills (and thus some workers) while replacing others. Since not everybody has the skills that go well with digital technologies, many can end up falling behind. Education and skills thus determine whether the promise of digital dividends is achieved, or whether technological advances translate into more inequality in a race between skills and technology.[113] Understanding this dynamic is critical: inequality will increase if more workers do not acquire the modern skills most in demand. But if education and training systems increase the supply of workers who meet the changes in skill demands, more workers would benefit from technological change and inequality could decrease.

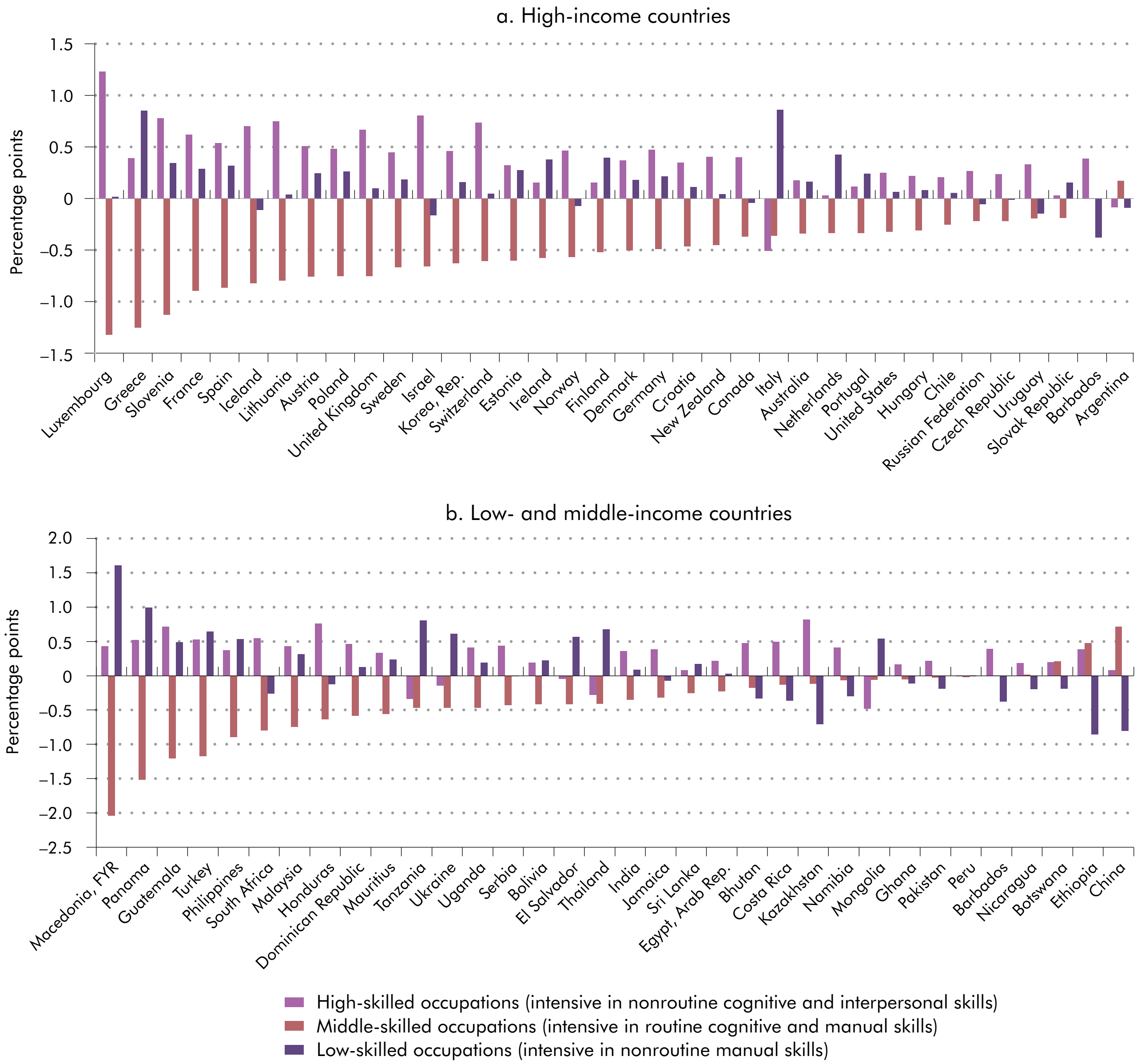
The race between skills and technology

With rising computing power, combined with the connectivity and informational value of the internet, digital technologies are taking on more tasks. They are particularly good at performing tasks that follow explicit, codifiable procedures—that is, routine tasks. Some of these tasks are cognitive, such as processing payrolls, keeping books, or doing arithmetic. Others are manual or physical, requiring simple motions and muscle power, such as driving a train or assembling goods. These tasks can be easily automated. Nonroutine tasks, by contrast, are less amenable to automation. Doing research, maintaining personal relationships, and designing new products have proven hard to automate; so have manual tasks that involve significant dexterity, such as cleaning and providing security services or personal care. Technology is even moving into areas once thought to be the exclusive domain of humans, such as driving or writing news articles.

So, the impact of digital technologies on jobs depends on the type of tasks and how technology either complements or substitutes workers in those tasks. A job comprises many tasks, each characterized by the skills most used to perform it (cognitive, socioemotional, or manual) and by how amenable it is to automation or codification (table 2.3). In some cases, technology augments labor by complementing workers. Both the researcher and the hairdresser do tasks that are nonroutine and not easily programmed into a computer, but technology makes the researcher (who uses more advanced skills at work) much more productive, while barely affecting the hairdresser. This means that technology is *skill-biased*.

Figure 2.15 The labor market is becoming polarized in both developed and developing countries

Annual average change in employment share, circa 1995–circa 2012



Sources: WDR 2016 team, based on ILO Laborsta (various years); I2D2 (World Bank, various years); National Bureau of Statistics of China (various years). Data at http://bit.do/WDR2016-Fig2_15.

Note: The figures display changes in employment shares between circa 1995 and circa 2012 for countries with at least seven years of data. The classification follows Autor 2014. High-skilled occupations include legislators, senior officials and managers, professionals, and 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. For the United States, comparable data could be accessed only for a short period (2003–08); consistent with Autor (2014), the observed polarization is limited in this period, with most of it having taken place in earlier years.

In other cases, workers are in jobs that are routine, whether mostly manual or mostly cognitive, and are susceptible to automation and to seeing their jobs profoundly transformed or vanishing. In these cases, technology is *labor-saving*. The fundamental questions then become: To what extent are different occupations and countries' labor markets affected by skill-biased and labor-saving digital technologies?

Table 2.3 Interactions between technology and skills at work

Ease of automation (technology is labor-saving)	Ease of complementarity (technology is labor-augmenting): High (tasks intensive in cognitive analytical and socioemotional skills)	Ease of complementarity (technology is labor-augmenting): Low (tasks intensive in manual skills)
High (routine tasks)	1 Bookkeepers, Proofreaders, Clerks	Machine operators, Cashiers, Typists 2
Low (nonroutine tasks)	Researchers, Teachers, Managers 4	Cleaners, Hairdressers, Street vendors 3

Source: WDR2016 team, adapted from Acemoglu and Autor 2011.

Note: Workers in occupations in quadrant 4 can benefit greatly because the majority of their tasks are difficult to automate, and the core of their work is in tasks in which digital technologies make them more productive. Occupations in quadrants 1 and 2 are composed of many tasks that can be easily automated. Productivity in occupations in quadrant 3 is by and large not directly affected by digital technologies.

And what are the typical characteristics of workers in occupations that, in the absence of effective policies, stand to gain or lose from technological change?

Skill-biased technological change and the new digital divide

As Brynjolfsson and McAfee write in *The Second Machine Age*, "There's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. But there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate."[114] So, recent skill-biased technological change favors workers with advanced skills (table 2.4). Not only is overall employment moving toward occupations intensive in these more advanced skills, but even within a given job, skill demands are similarly shifting.

Because of this, two sets of skills are increasingly important in today's labor markets: ICT skills and

Table 2.4 Recent evidence on skill-biased technological change

Authors	Country	Findings
Akerman, Gaarder, and Mogstad (2015)	Norway	Broadband adoption in firms complements skilled workers performing nonroutine tasks and substitutes for workers performing routine tasks.
Autor, Katz, and Kearney (2008)	United States	Patterns of wage inequality are best explained by a modified version of the skill-biased technical change hypothesis, which emphasizes information technology in complementing abstract (high-education) tasks and substituting for routine (middle-education) tasks.
Autor, Katz, and Krueger (1998)	United States	Digital technologies widen wage differentials. Skill upgrading within industries accounts for most of the growth in the relative demand for college workers, especially in more computer-intensive industries.
Berman, Somanathan, and Tan (2005)	India	Trade openness and reform promote technology adoption and diffusion and increase the nonproduction worker shares of employment and total wages in manufacturing, even within industries.
Gaggl and Wright (2014)	United Kingdom	A tax allowance on ICT investments among small firms leads, in the short run, to an increase in demand for nonroutine cognitive-intensive work, some substitution of routine cognitive work, and no effect on manual work.
Marouani and Nilsson (2014)	Malaysia	Without skill-biased technological change, skilled wage earners should expect lower wages and higher unemployment, and unskilled labor should expect higher wages and lower unemployment.
Srour, Taymaz, and Vivarelli (2013)	Turkey	Domestic and imported technologies increase the demand for skilled labor five to six times more than the corresponding demand for unskilled labor.

Source: WDR 2016 team.

Note: ICT = information and communication technology.

Box 2.7 Skills wanted: Key concepts

Beyond foundational cognitive skills, such as basic literacy and math, a well-educated worker in a modern economy needs to develop the following skills:

Nonroutine, higher-order cognitive skills. These refer to the ability to understand complex ideas, deal with complex information processing, adapt effectively to the work environment, learn from experience, engage in various forms of reasoning, to overcome obstacles by critical thought.[a] More specifically, these include skills such as unstructured problem solving, and critical thinking, learning, and reasoning.

Technical skills, including information and communication technology (ICT) skills. Technical skills are those abilities needed to carry out one's job, such as the ability to repair a water leakage for a plumber, the knowledge to operate a machine for a worker at a factory, or the knowledge to work with a software for a person at a bank.[b] They also include ICT skills. ICT skills refer to the effective application of ICT systems and devices, and range from ICT specialists who have the ability to develop, operate, and maintain ICT systems, to basic ICT users, who are competent users of the mainstream tools needed in their working life (e-mail, Excel, Outlook, PowerPoint, Word).[c]

Nonroutine interpersonal, socioemotional skills. Socioemotional skills (also called soft or noncognitive skills) encompass a broad range of malleable skills, behaviors, attitudes, and personality traits that enable individuals to navigate interpersonal and social situations effectively.[d] These include grit or the perseverance to finish a job or achieve a long-term goal, working in teams, punctuality, organization, commitment, creativity, and honesty.

a. Neisser and others 1996.
b. Cunningham and Villasenor 2014.
c. European Commission (EC 2004); OECD 2004.
d. Cunningham and Villasenor 2014.

higher-order cognitive and socioemotional skills (box 2.7). Since 2000, the ICT intensity of employment has increased by almost 10 percent in low- and middle-income countries, almost twice as fast, on average, as in high-income economies (figure 2.16). The share of employment in occupations intensive in nonroutine cognitive and socioemotional skills has also increased in low- and middle-income countries, from 19 to 23 percent. However, the decline in occupations intensive in routine skills was even larger, from 50 to 44 percent (figure 2.17).[115] This is the driving force behind the polarization of labor markets. The new economy offers, therefore, a premium for ICT skills, strong foundational cognitive and socioemotional skills, and for more advanced nonroutine 21st-century skills such as critical thinking, complex problem-solving, creativity, and expert communication. In fact, workers using these "new economy" skills and technology are better remunerated—by 25–40 percent—than their peers with the same level of education but performing traditional tasks and jobs.[116]

Poor digital literacy limits the productive use of digital technologies

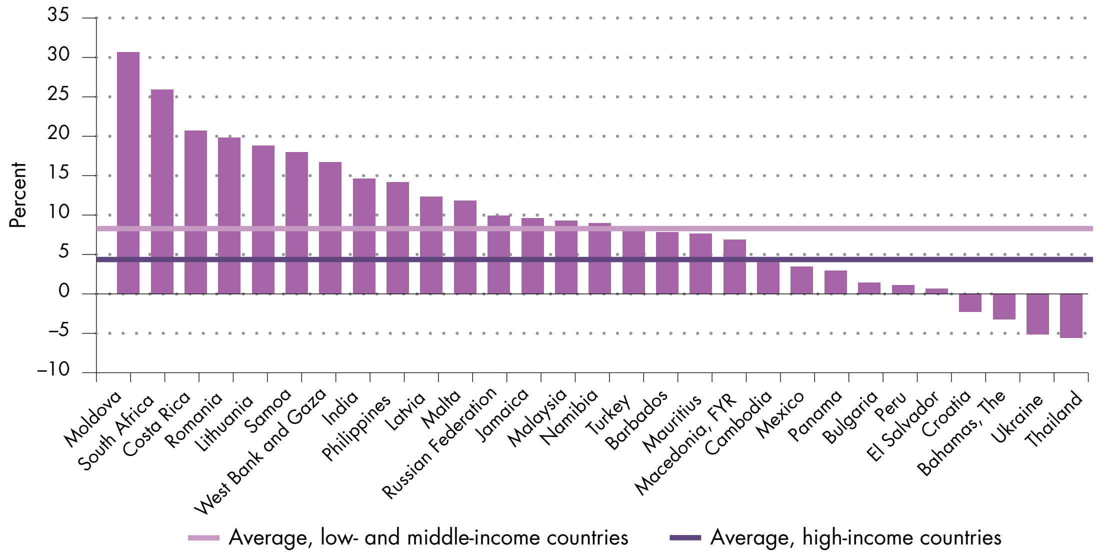
It is hard to use the internet when, even among youth, more than half have a level of functional literacy below what will enable them to participate productively in life, as in Albania, Indonesia, Jordan, Malaysia, or Peru.[117] About three-quarters of third-graders in Mali and Uganda cannot read.[118] Beyond basic literacy, ICT skills are deficient. In Africa, 7 in 10 people who do not use the internet say they just don't know how to use it, and almost 4 in 10 say they do not know what the internet is.[119] In high-income Poland and the Slovak Republic, one-fifth of adults cannot use a computer.[120]

The use of ICT skills at work is unequal, but their importance is growing. On average, one-third of urban workers (and 20 percent of the bottom 40 in urban areas) in developing countries use a computer at work, for example (figure 2.18). This number is likely to raise quickly, with ICT use increasing as countries become richer and as work becomes more complex (figures 2.16 and 2.19).

Employers are looking for ICT skills, but cannot find them. In the former Yugoslav Republic of Macedonia, 43 percent of firms say ICT skills are very important for workers, but more than 20 percent say that workers lack them.[121] Although the same workers lacking ICT skills often also lack other skills or face other barriers to employment, digital literacy limits their employment opportunities (figure 2.20). The use of digital technologies at work is associated with

Figure 2.16 Employment is becoming more intensive in the use of digital technologies

Change in the ICT intensity of employment, 2000–12

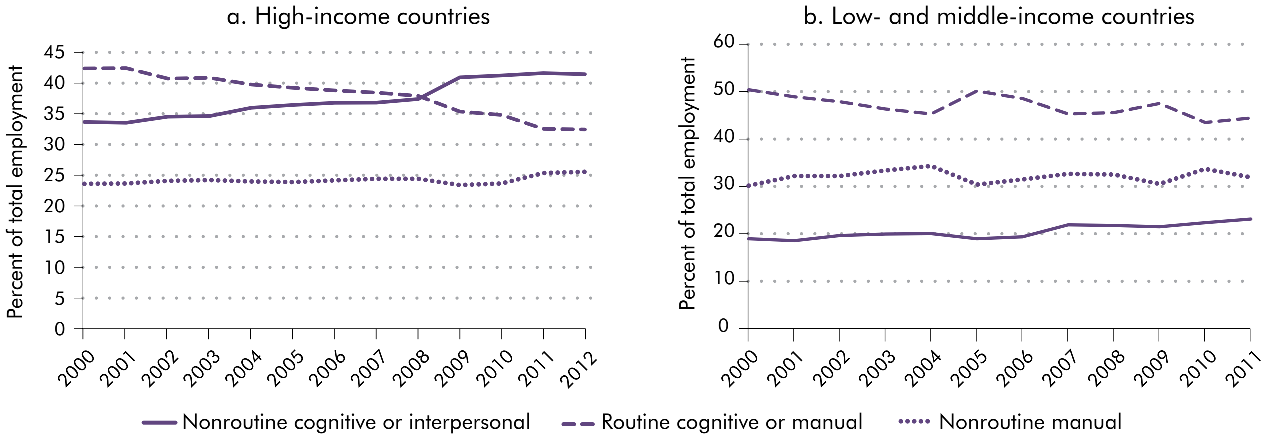


Source: WDR 2016 team, based on Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, using ILO Laborsta (various years). Data at http://bit.do/WDR2016-Fig2_16.

Note: ICT (information and communication technology) intensity of employment is based on an index between 0 (no use of technology at work) and 19 (most use of technology at work), averaged by occupation (at the three-digit level) and weighted by employment.

Figure 2.17 Nonroutine skills are becoming more important over time

Employment composition by type of occupation according to skills requirements, 2000–12



Source: WDR 2016 team, based on ILO Laborsta (various years). Data at http://bit.do/WDR2016-Fig2_17.

Note: Data are simple cross-country averages. Classification of occupations according to skills requirements follows Autor 2014 and reflects the types of skills most intensely used in each occupation.

higher earnings, even after accounting for educational attainment. Across a sample of eight developing countries, the return associated with using ICT at work is around 40 percent.[122] In Brazil, and focusing on workers most similar to one another, returns to internet use are about 10 percent.[123]

High-order cognitive and socioemotional skills are more important in the new economy

Technological progress is redefining the nature and content of jobs. Some of today's jobs are new and require new skills—software publishers, data scientists, enterprise mobile developers. Others have long existed but have been transformed. Consider, for example, the job description of an accountant in the 1970s and today. Specialized softwares have automated many of the accountant's original tasks, shifting her job toward more advisory services and critical thinking. Employers now demand more "new economy" skills: that is, high-order cognitive and socioemotional skills, as evidenced in countries as diverse as Brazil, Malaysia, and FYR Macedonia (figure 2.21).

At the aggregate level and within firms, new technologies substitute for workers performing routine tasks, while making skilled workers who execute nonroutine abstract tasks more productive.[124] Across 28 studies, more than half of the top five skills demanded by employers are socioemotional, another 30 percent are higher-order cognitive, and 16 percent are technical.[125] High-order cognitive skills include reasoning, problem solving, and critical thinking, while socioemotional skills refer to behavior, personality traits, and attitudes, such as grit, teamwork, self-discipline, dependability, and leadership. These are things that are still hard for technology to replicate.

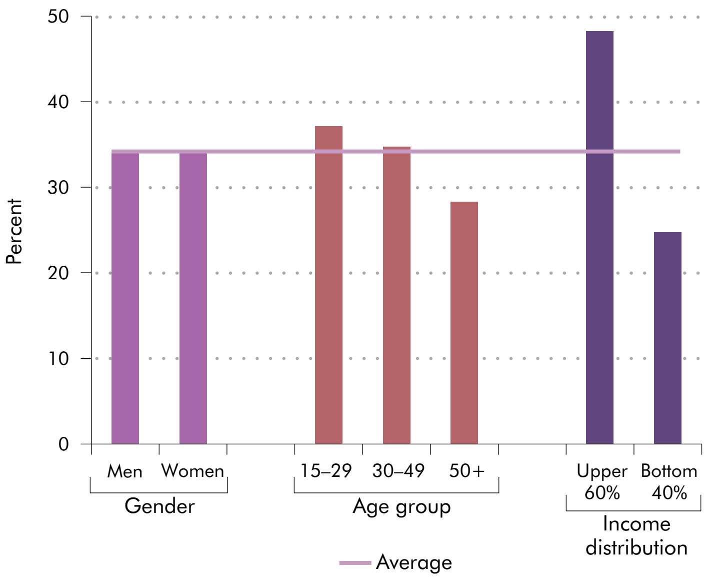
These new economy skills pay off. Workers with strong cognitive and socioemotional skills in Armenia, Georgia, the Kyrgyz Republic, Tajikistan, and Vietnam are more likely to be employed and have better-quality jobs.[126] In Vietnam, within a given industry, performing nonroutine analytical tasks carries a 23-percent earnings premium, and interactive (that is, interpersonal) tasks a 13-percent premium, whether combined with routine or nonroutine tasks (figure 2.22). In Armenia and Georgia, the premium for problem solving and learning new things is close to 20 percent.[127] More generally, in 12 of 16 mostly developing countries, wages in nonroutine occupations increased significantly more than wages in routine occupations between 2005 and 2011.[128]

In addition to technological change, other factors help explain these global labor market trends. Trade, urbanization, structural transformation, and globalization fundamentally shape labor markets and in a number of cases are likely to be even more important than technology. In some Latin American countries, for example, commodity-driven economic booms have boosted low-wage earnings and show no polarization at the aggregate level. Moreover, distinguishing among factors is more difficult because they are related to one another.[129]

Yet technological change seems to be an important part of the explanation. First, occupations most intensive in the use of digital technologies are also most intensive in nonroutine cognitive and interpersonal skills (figure 2.23). Second, globalization and trade do not fully explain the observed polarization.[130] Given

Figure 2.18 In developing countries, one-third of urban workers use digital technology at work

Urban workers who use a computer at work, conditional on working

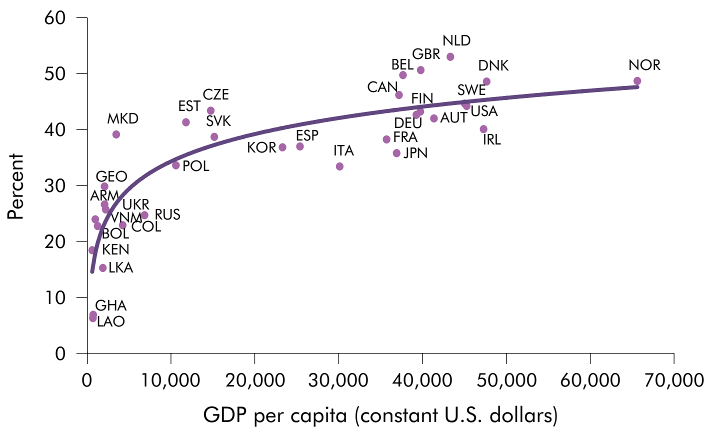


Source: WDR 2016 team, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_18.

Note: "Average" refers to the average use of technology among all urban workers in 11 countries where the STEP survey was conducted. "Upper 60%" and "Bottom 40%" refer to asset distribution of individuals' households.

Figure 2.19 Employment becomes more intensive in ICT use as economies grow

Share of employment in high–ICT-intensity occupations, circa 2013



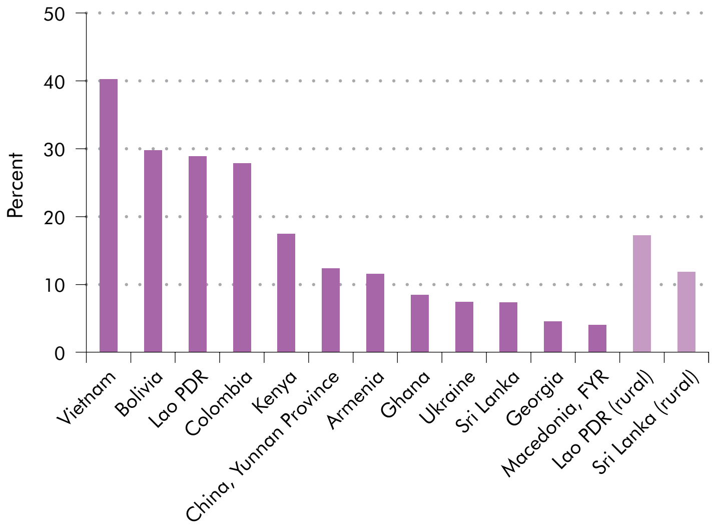
Source: Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, based on STEP (World Bank, various years), PIAAC household surveys, and World Development Indicators (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_19.

Note: GDP = gross domestic product; ICT = information and communication technology; PIAAC = Programme for the International Assessment of Adult Competencies.

the weight of China in manufacturing supply chains, the decline in routine labor in the rest of the world could simply be the result of a shift of routine labor to China's manufacturing sector. Between 2000 and 2010, the share of employment in routine occupations

Figure 2.20 Lack of ICT skills is often a constraint to employment

Share of working-age individuals in urban areas who report that lack of ICT skills is a barrier to employment and higher earnings, circa 2013



Source: WDR 2016 team, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_20.

Note: ICT = information and communication technology.

in China rose from 19 to 27 percent (see figure 2.15, panel b). Yet manufacturing employment in China is also polarizing, for the increase in routine labor is explained by the mechanization of agriculture. Moreover, across most countries with relevant data, employment is polarizing even within services, suggesting an additional effect in skill demand over and above what can be explained by trade or the structural transformation of developing economies.[131] This evidence is also consistent with the evidence for OECD countries linking changes in skills requirements to technological changes, even within occupations.[132]

Labor-saving technologies: Automation and job displacement

There is concern, especially in advanced countries, that technology is killing jobs and depressing wages.[133] Manufacturers are using machines that substitute for workers in warehouses or auto plants. More than 200,000 industrial robots come into use each year, and that number is rising.[134] Increasingly, automation is taking place in services.[135] In call centers, technology can answer routine customer service requests. In retail, technology and "big data" suggest what to buy. Software is handling accounting, translations, and paralegal services. Travel agents have all but disappeared, with three-quarters of all travel in the United States now booked online.[136] In the public sector too, digital technologies are substituting for workers performing routine tasks. In the Indonesian Treasury, electronic budget planning and execution is linked to job redefinitions and reassignments for around 5,000 workers (of 8,000) who previously processed payments, disbursements, and cash management.[137] In Pakistan, the automation of systems in the central bank made 3,000 of 12,000 employees redundant (mostly low-skilled staff). The savings boosted the salaries of remaining employees.[138]

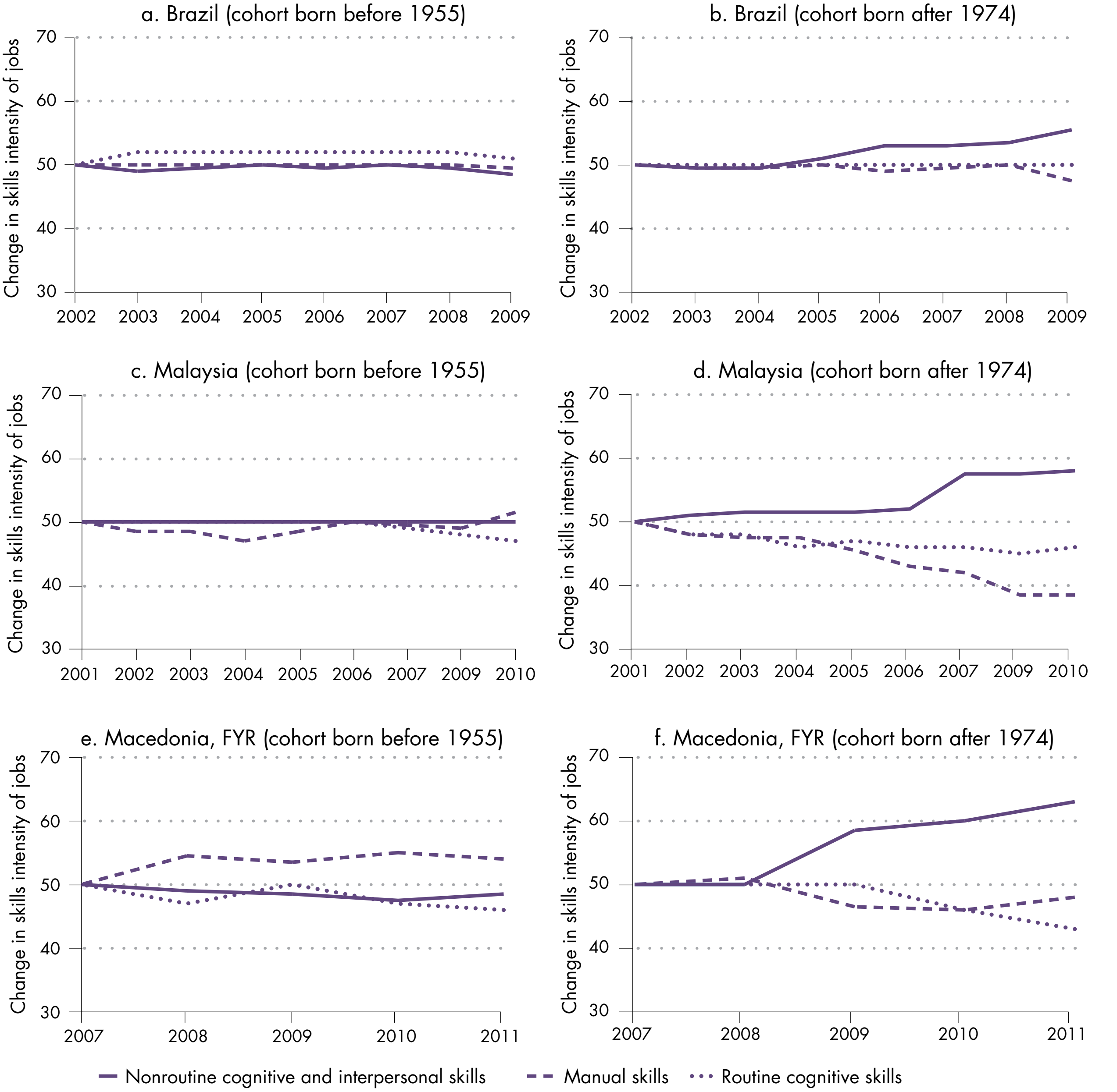
Two-thirds of all jobs could be susceptible to automation in developing countries in coming decades, from a pure technological standpoint (figure 2.24). Estimates for the United States and Europe range between 50 and 60 percent of jobs.[139] Given expected advances in artificial intelligence, falling ICT prices, and increased coverage of the internet, the potential for automation is clear. Rapid automation of a large number of jobs would be problematic: It may take time for new jobs to be created, and even if they are, retraining takes time and may be difficult.

Yet, even if technologically feasible, large-scale net job destruction due to automation should not be a concern for most developing countries in the short term. Even in the United States, on average, there were no net employment declines in local labor markets most susceptible to automation (that is, those specialized in routine, task-intensive occupations).[140] New jobs and new tasks in existing occupations are created. Machines and digital technology are not perfect or even good substitutes for many tasks (at least not yet), especially those requiring adaptability, common sense, and creativity.[141] The expansion of automated teller machines (ATMs) in banks went hand-in-hand with an expansion of bank transactions, branches, and employment. Cashiers continue to do some of the things that ATMs do, but they also do other things, such as client support, where human interaction remains important.[142]

Full automation of jobs takes time, even in the developed world. In the United Kingdom, an exogenous increase in ICT investment between 2000 and 2004 led to a short-term increase in the demand for nonroutine skills, but only to the limited substitution of routine workers during that period.[143] Why? Because it takes time to make the necessary organizational changes (chapter 1), and because labor reorganizations tend to happen in periods of recession rather than in booms.[144] Not all disruptive technologies are adopted quickly, implemented fully, or yield immediate benefits.[145] Barriers to technology adoption, lower wages, and a higher prevalence of jobs based on manual dexterity in developing countries mean that automation is likely to be slower and less widespread there (see figure 2.24). But as wages rise, and in countries with

Figure 2.21 **Nonroutine analytical and socioemotional skills are becoming more important, especially in jobs performed by younger cohorts**

Evolution of the skills intensity of jobs, measured as mean skills percentile of base year, Brazil, Malaysia, and Macedonia, FYR, various years, 2001–11



Sources: WDR 2016 team, based on Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); East Asia and Pacific Poverty (EAPPOV) Database (World Bank, various years); and Europe and Central Asia Poverty (ECAPOV) Database (World Bank, various years); and following Autor, Levy, and Murnane 2003; Acemoglu and Autor 2011; Aedo and others 2013; Arias and others 2014. Data at http://bit.do/WDR2016-Fig2_21.

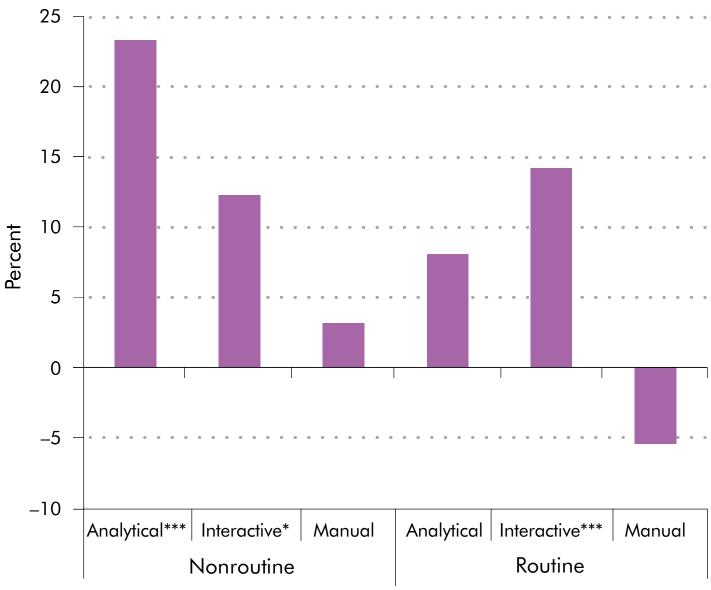
Note: The y-axis represents the percentile of the skill distribution for jobs held by each cohort in any given year, with respect to the corresponding median skills intensity of jobs held by that cohort in the initial year. An increase means that jobs increased in intensity in that particular skill. For Malaysia (panels c and d), data for 2008 were unavailable.

large manufacturing or offshored activities, there is more (and faster) scope for automation.

Concerns about automation are not new. Past fears of technology leading to mass unemployment (and boredom)—from the Luddites in the midst of the Industrial Revolution to Keynes during the Great Depression—have gone unrealized (box 2.8).[146] The assembly line, after all, replaced the artisans making carriages. Back in the 1960s, with the creation in the United States of the National Commission on

Figure 2.22 New economy skills, beyond levels of education, pay off

Urban Vietnam: Average return to different task combinations, controlling for education and demographics, 2012



Source: Bodewig and others 2014. Data at http://bit.do/WDR2016-Fig2_22.

Note: Returns are estimated using a wage regression that controls for education, sex, experience, and economic sector.

Significance level: * = 10 percent, *** = 1 percent.

Technology, Automation, and Economic Progress, there were also concerns about automation in this wave of technological change. Unemployment fears have gone unrealized because new technologies, by fostering entrepreneurship and improving productivity and the allocation of resources, have led in due time to more jobs elsewhere.

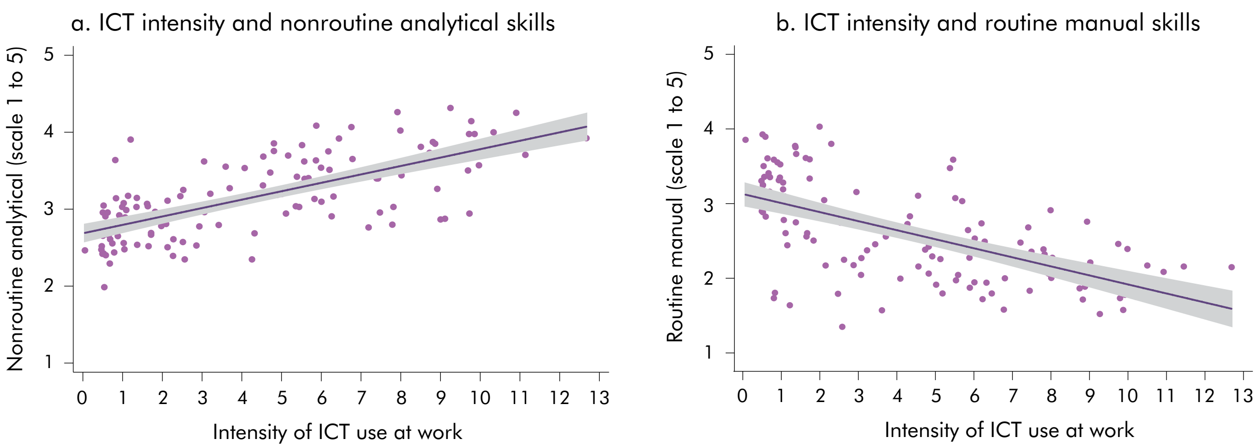
Will this time be different? Large factories and electrification did lead, as now, to a polarization of employment by hollowing out the middle of the skill distribution. The share of employment of blue-collar workers in manufacturing fell from 39 percent in 1850 to 23 percent in 1910, as new capital goods allowed factory owners to unbundle and simplify tasks that could now be performed by unskilled workers. Electrification increased the relative demand for workers intensive in clerical and managerial skills compared with manual and dexterity skills among white-collar workers. Among blue-collar workers, it increased the demand for manual workers relative to the demand for workers performing tasks intensive in dexterity needed to operate machines before electrification.[147]

Despite these similarities, the biggest difference from past waves of technological progress is that the polarization of the labor market today is affecting both blue-collar and white-collar workers.[148] It is probably easier for white-collar workers to transition to other white-collar jobs, but in the aggregate, there may be fewer well-paying jobs for a large and diverse pool of potentially dislocated workers. Even if all those jobs do not fully disappear—unlikely in a short period—they will be significantly transformed.

And here is where a second lesson from history is relevant. Individuals and governments adapted to technological change, but this process took time and required deep institutional changes in education,

Figure 2.23 Digital technologies go hand in hand with nonroutine new economy skills

ICT intensity and skills intensity, by occupation

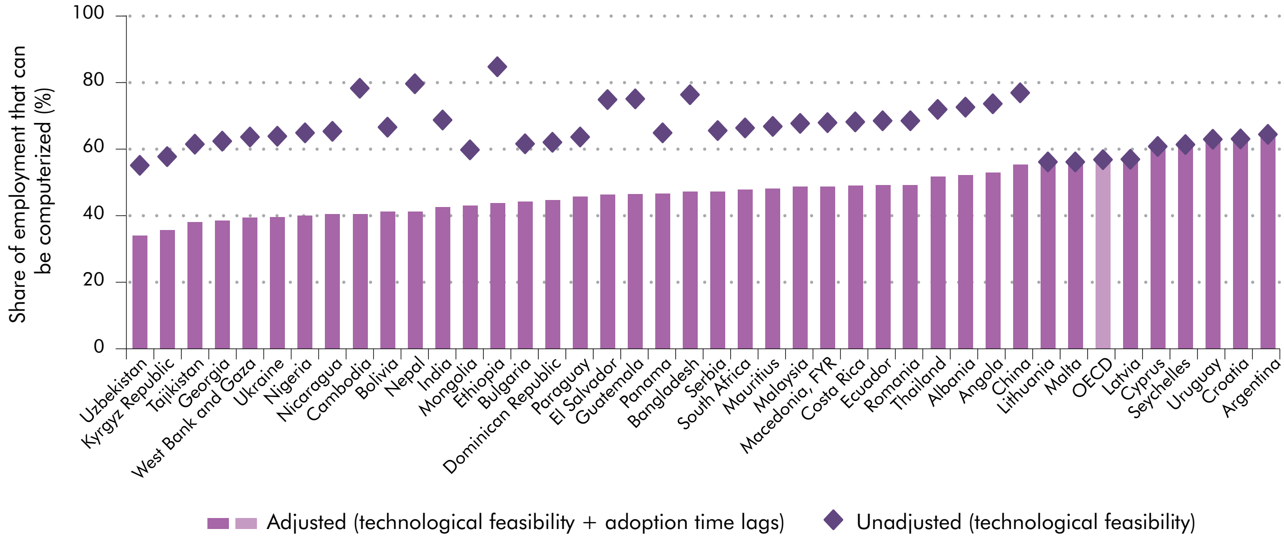


Source: Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016, based on STEP household surveys (World Bank, various years). Data at http://bit.do/WDR2016-Fig2_23.

Note: Ninety-five percent confidence intervals. The y-axis is a standardized score (from 1 to 5) that reflects the intensity of the use of the particular type of skills as estimated by Autor, Levy, and Murnane (2003) and expanded by Acemoglu and Autor 2011. The intensity of ICT use is an index between 0 (no use of technology at work) and 19 (most use of technology at work). ICT intensity is averaged by occupation. ICT = information and communication technology.

Figure 2.24 From a technological standpoint, two-thirds of all jobs are susceptible to automation in the developing world, but the effects are moderated by lower wages and slower technology adoption

Estimated share of employment that is susceptible to automation, latest year



Sources: WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); South Asia Region MicroDatabase (SARMD) (World Bank, various years); Europe and Central Asia Poverty (ECAPOV) Database (World Bank, various years); East Asia and Pacific Region Poverty (EAPPOV) Database (World Bank, various years); the I2D2 dataset (International Income Distribution Database; World Bank, various years); ILO Laborsta database (various years); the National Bureau of Statistics of China (various years); Frey and Osborne 2013; Comin and Hobjin 2010. Data at http://bit.do/WDR2016-Fig2_24.

Note: The *unadjusted* probabilities of automation for occupation are from Frey and Osborne (2013), weighted by employment. The *adjusted* probabilities account for the slower pace of technology adoption in poorer countries, using the adoption lag of earlier technologies (Comin and Mestieri 2013). See Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. OECD = Organisation for Economic Co-operation and Development.

Box 2.8 Concerns about technological unemployment are not new

We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come—namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour.

—John Maynard Keynes
"Economic Possibilities for Our Grandchildren," 1931

The situation will have been made the more serious by the advances of automation. The world of A.D. 2014 will have few routine jobs that cannot be done better by some machine than by any human being. Mankind will therefore have become largely a race of machine tenders. Schools will have to be oriented in this direction . . . It is not only the techniques of teaching that will advance, however, but also the subject matter that will change. Even so, mankind will suffer badly from the disease of boredom . . . The lucky few who can be involved in creative work of any sort will be the true elite of mankind, for they alone will do more than serve a machine.

—Isaac Asimov
"Visit to the World's Fair of 2014," 1964

social protection, and labor regulations.[149] The answer to whether things may turn out differently this time, while unsatisfactory, is: "It depends." It depends on the ability and speed of creating new jobs elsewhere in the economy (chapter 1). It depends on how individuals, firms, and policy makers respond to the change in skills requirements. And it depends on how well the social protection system supports dislocated workers.

The future of jobs

Be an expensive complement (stats knowhow) to something that's getting cheaper (data).

—Hal Varian, Chief Economist, Google, 2014

Technological progress makes the jobs challenge more complex. Digital and mechanical technologies, and deindustrialization, mean that the manufacturing sector is likely to generate fewer jobs than in the past, especially for unskilled workers.[150] ICT manufacturing can be expected to create jobs, although mostly high-skilled and likely concentrated in specific countries, as now. Since manufacturing jobs have been an important source of better-paying jobs as workers move out of agriculture, this is an important development. The service sector is also increasingly being automated. Of particular concern are jobs that have so far actually grown thanks to digital technologies, such as low- and middle-skilled call center jobs. Employment in the ICT service industry, even more than its manufacturing counterpart, is expected to grow, but also among higher-skilled workers in leading countries.

Future employment growth is likely to come from jobs that cannot be fully or partially automated, largely outside the ICT industry. New jobs are also likely to emerge in the digital economy—in the analysis of data such as data scientists, in the development and maintenance of apps and other software, and in support services. New opportunities will also arise in ICT-enabled services, such as the on-demand economy. But the significance for employment generation, especially in most developing countries, is likely to be small.

The potential for employment creation lies in the rest of the economy, as digital technologies allow businesses to expand. Among the low-skilled, some services that must be delivered face-to-face or require awareness and situational adaptability (housekeepers, hairdressers) are likely to grow. Among the high-skilled, occupations will rely on modern skills involving creativity and social interactions. Some observers call this the polarization in "the high-tech, high-touch" economy.[151]

Although impossible to predict in advance, jobs are likely to arise in new industries and occupations. New industries arising from digital technologies since 2000 account for only 0.5 percent of employment in the United States,[152] and there is evidence of (young) skilled workers having to take on less-skilled jobs.[153] But historically, economies have been able to create enough jobs through technological change. The initial labor market polarization caused by factories in the 19th century in the United States led to an upskilling of employment as increases in middle-skilled sales and clerical employment compensated for the decline in blue-collar jobs. With electrification, displaced workers typically moved to lower-skilled jobs at lower wages, such as truck drivers, but large increases in new middle-skill employment outweighed the decline in blue-collar employment.[154] While the steam engine in the 18th century led to the disappearance of coachmen for horse-drawn carriages[155] and to the substitution of workers in mining, in due time it also was at the center of steam-powered boats, locomotives, and automobiles. Mechanics, road building and maintenance, and dealerships have created many jobs of diverse skill profiles ever since.

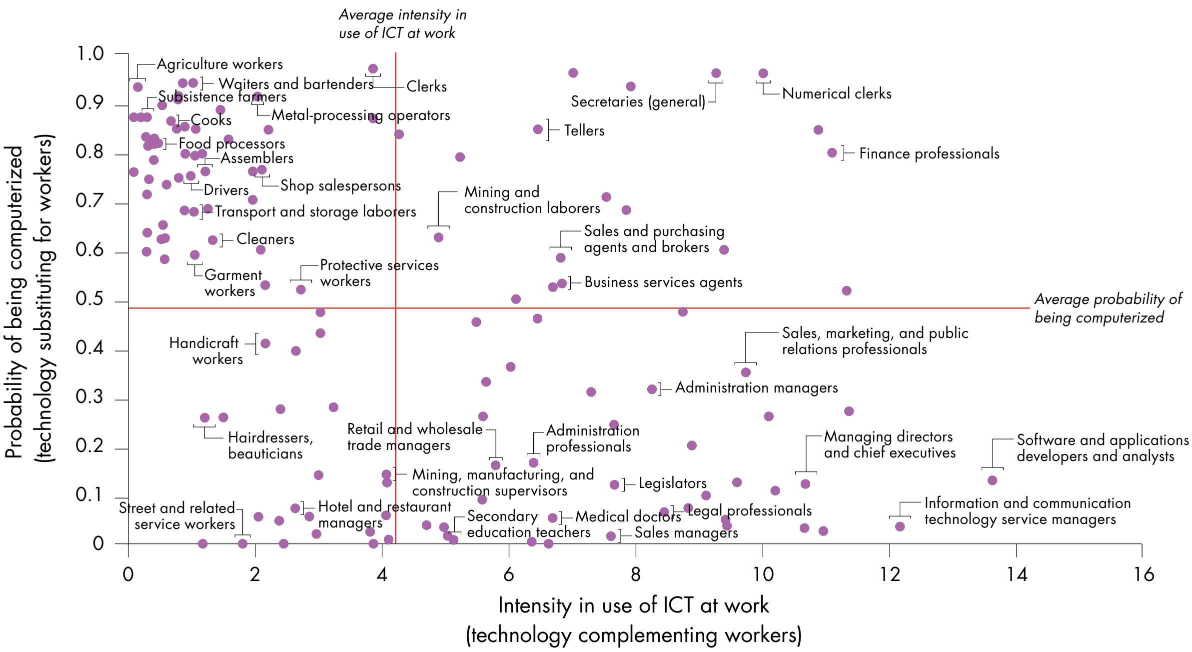
Yet as a result of this process of job creation and destruction, technological change disrupts labor markets and can hurt individuals whose skills are substituted by technology, because they often do not have the skills required in many of the new jobs. Even for those who stay within the same occupations, jobs will be transformed, requiring modern skills. The speed of these changes appears to be accelerating, intensifying creative destruction and the pace of labor market changes.

Since digital technologies have different applicability to different kinds of work, the extent of disruption across countries will reflect differences in economic and occupational structures. Numerical clerks or secretaries, often users of digital technologies, also perform many tasks that can be easily automated. Managers or software developers, by contrast, while intensively using digital technologies, also complement them well, so they are not easily substituted by machines. And for occupations that use little technology, some are hard to automate, such as hairdressers, while others could be automated, such as assemblers (figure 2.25).

More advanced economies can expect larger disruptions in the near future since they use more technology at work and are experiencing faster changes in skill requirements (figure 2.26).[156] And while they have smaller shares of employment in routine occupations susceptible to automation, their higher wages make it easier for automation to be economically viable. Low- and middle-income countries can also expect substantial disruptions, albeit with a time lag, given their rapid technological adoption and large number of workers in routine occupations. Their low skill base suggests important challenges ahead, however. In poorer countries, where wages are lower and technological adoption is slower (chapter 1), the disruptions are likely to arrive more slowly, giving more time for policies and institutions to adapt. All this has implications for

Figure 2.25 The interaction between technology and jobs varies by occupation

Probability of being computerized and intensity in use of ICT at work, by occupation



Sources: WDR 2016 team, based on STEP household surveys (World Bank, various years) and Frey and Osborne 2013. Data at http://bit.do/WDR2016-Fig2_25.

Note: The probability of being computerized is obtained from Frey and Osborne (2013). ICT intensity is an index between 0 (no use of technology) and 19 (most use of technology). ICT = information and communication technology. The red lines represent the average values of ICT intensity (x-axis) and of computerization (y-axis) across the pooled sample of 10 developing countries with STEP household surveys.

whether countries need not just to develop modern skills among children and youth, but also to come up with a strategy for the retraining and lifelong learning of the current stock of (older) workers.

The challenge is to start reforms today to maximize the digital dividends and to prepare for any disruptions. Even if expected labor market changes are similar in Malaysia and South Africa, Poland and Turkey, or Finland and Italy, skill systems vary widely and not all are prepared to equip workers with skills that complement technology. This process needs to start very early in life, and education and training systems are notoriously difficult to change. So, any reform takes many years to have effects, which is why there is a race between skills and technology. Some skill systems are well-positioned, but for many others, skills—and hence, people—are losing the race.

Making the internet work for everyone

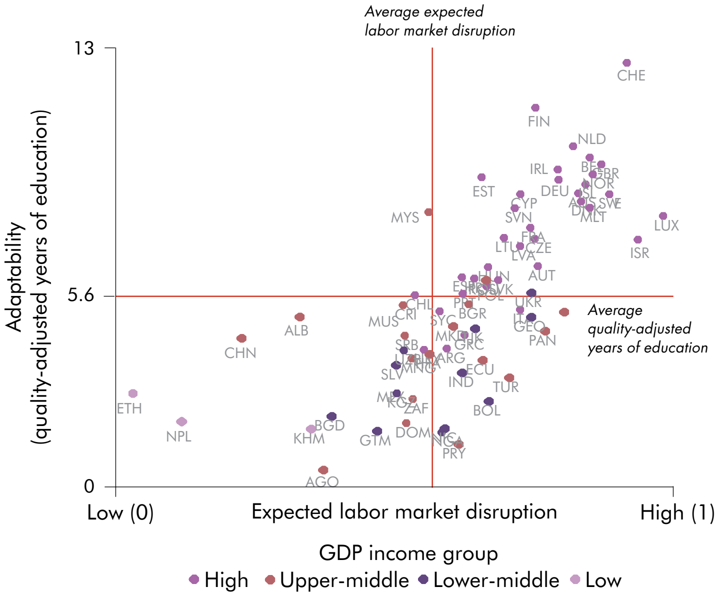
To design policy responses to technological change, it is important to understand who the changes are likely to affect the most, and how the process plays out both in terms of employment and earnings. As discussed, employment is likely to polarize, with routine occupations losing ground to nonroutine occupations. These changes in labor demand have in turn implications for earnings. But employment polarization does not necessarily mean wage polarization.

Three interrelated factors mediate the impact of digital technologies on earnings:

- *Complementarity with technology.* Workers in jobs that use and complement technology are likely to see both an increase in employment and an increase in earnings because of higher productivity. This is the case for workers who use nonroutine cognitive skills and ICT skills. Workers in routine occupations, however, will see less demand for their skills, bringing down both their employment and their wages.
- *Product demand.* If workers produce goods or services that consumers keep buying as they get richer or as the price declines, increases in productivity can translate into increases in wages. This is often the case for workers with nonroutine skills producing, say, knowledge, management expertise, or medical services. If not, increases in productivity can lead to lower employment and earnings in that sector because fewer workers can satisfy demand, as for many agricultural goods.

Figure 2.26 The key policy challenge: Adapting the skills agenda to expected labor market disruptions

Expected labor market disruption and quality-adjusted years of education



Sources: WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); SHIP (World Bank, various years); SEDLAC (Cedlas and the World Bank); SARMD (World Bank, various years); ECAPOV (World Bank, various years); EAPPOV (World Bank, various years); the National Bureau of Statistics of China (various years); ILO Laborsta database (various years); World Development Indicators (World Bank, various years); World Economic Forum's Competitiveness Index (WEF, various years). Data at http://bit.do/WDR2016-Fig2_26.

Note: Labor market disruption is an index that goes from 0 (no disruption) to 1 (highest disruption). It is the standardized summation of two components, equally weighted: the probability of an average job being computerized (Frey and Osborne 2013, and adjusting for adoption lags), and the intensity of ICT use at work. For each country, the ICT intensity of employment corresponds to the average for countries at the next level of development, to be more forward-looking. The quality-adjusted years of education are constructed by adjusting average years of education for each country with the World Economic Forum's quality-of-education indicator. For example, if a country has, on average, 10 years of education and scores 3.5 on the indicator (which ranges from 0 to 7), its quality-adjusted years of education are 5. See Monroy-Taborda, Moreno, and Santos, forthcoming, for the WDR 2016. GDP = gross domestic product.

- *Labor supply.* The higher the skill requirements for a job, the more difficult it is for new workers to enter that market. So, higher demand for workers would translate into higher wages. If, however, it is easy to retrain for a new job or skill requirements are low, there can be downward pressure on wages because of increased competition. Workers in nonroutine cognitive occupations are likely to see their higher productivity rewarded as higher earnings because entry barriers are high. But low-skilled workers in nonroutine manual occupations are likely to see their earnings fall over time as middle-skilled workers in routine occupations are displaced and start competing for the available jobs in low-paying occupations (table 2.5).[157]

Therefore, the main winners from technological change will have and use new economy skills and gain employment in nonroutine cognitive occupations.

Table 2.5 Expected impacts of technological change on employment and earnings

Type of occupation (by skills intensity)	Expected impact on	
	Employment	**Earnings**
Nonroutine cognitive	Positive	Positive
Routine cognitive and manual	Negative	Negative
Nonroutine manual	Positive	Negative

Source: WDR 2016 team, based on Autor 2014.

The young, the better educated, and those already better off are most likely to benefit from digital technologies—with older workers, those with less education, and the poor falling behind. The former group is more likely to have more advanced skills—especially cognitive and ICT skills—regardless of their occupation or work status.[158] In addition, these groups are disproportionately likely to be in, or to move into, occupations that pay well and are likely to grow in the future—those intensive in nonroutine skills (figure 2.27).[159] Recent evidence from the United States shows that there has been a marked decline in the rate at which workers transition into routine employment (particularly among the young) but that women and those with higher education levels have found it easier to adjust to these changes by moving into the high-paying, nonroutine cognitive jobs.[160]

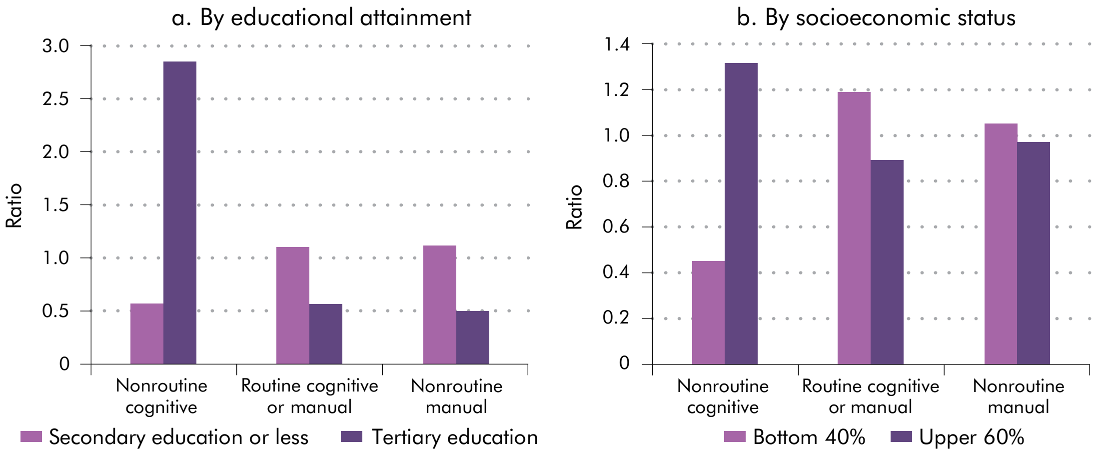
A big challenge for policy makers, especially in rapidly aging societies, is managing skill obsolescence. Recall that the surge in the demand for new economy skills has been concentrated among young workers (see figure 2.21). Digital technologies accelerate the depreciation of skills and work experience, affecting especially older workers (box 2.9). But obsolescence is not destiny or the same for all types of skills. Most literature argues that younger workers have a comparative advantage in tasks where problem solving, learning, and speed are important ("fluid" abilities), and older workers have an advantage when experience and verbal abilities matter more ("crystallized" abilities).[161] But evidence from Germany shows that workers in their 50s experienced a more rapid growth in tasks intense in fluid cognitive skills than those in their 30s.[162] Box 2.10 examines the gender impacts in more depth.

A policy agenda

Digital technologies improve overall welfare and can reduce poverty, but without complementary policies, many benefits can go unrealized and inequality can increase. To capitalize on the benefits—and to do

Figure 2.27 The less educated and the bottom 40 percent of the welfare distribution are most vulnerable to technological changes in the labor market

Ratio of employment by occupation type to total employment



Source: WDR 2016 team, based on the I2D2 dataset (International Income Distribution Database; World Bank, various years). Data cover 117 countries. "Bottom 40%" and "Upper 60%" refer to the welfare distribution (either of income or consumption) of individuals' households. Classification of occupations follows Autor 2014. Data at http://bit.do/WDR2016-Fig2_27.

Note: A ratio higher than 1 means that workers with the given level of education are disproportionately likely to be in the given occupation type. A ratio lower than 1 means that workers are relatively unlikely to be in a given occupation type.

so without leaving people behind—internet access (chapter 4) needs to be complemented with an "analog" policy agenda. In addition to supporting entrepreneurship and innovation to expand businesses and job opportunities, this agenda should ensure that education and training systems, labor regulations, and social protection institutions support all workers in seizing the opportunities that the internet generates (chapter 5).

The most crucial element is skills development. A modern economy requires workers with modern skills. For people to become online workers and traders, farmers to use technology to become more productive, or for workers to access modern,

Box 2.9 The challenge of keeping up with new technologies in Mexico

Technology is making many skills obsolete and reducing the returns to experience, especially among older workers.

In Mexico, as in other Latin American countries, wage inequality has declined since 2000. A declining skill premium has been one of the drivers of this trend because the wages of the low-skilled rose and those of the high-skilled fell. The average hourly wage for college-educated workers fell 2 percent a year between 2001 and 2014.

Why have high-skilled wages declined in Mexico, when in most countries, especially outside of Latin America, returns to tertiary education continue to rise (despite increasing educational attainment everywhere)? It could simply be that the supply of educated workers has outpaced demand for them. But there are three alternative explanations for the decline in relative wages of skilled workers: low-quality tertiary educated graduates, a skills mismatch among young workers, or skills obsolescence among older workers.

New research finds that the fall in the skills premium is driven at least partly by skills obsolescence among older workers. First, the earnings of the oldest cohort, above age 50, declined fastest (40 percent during the period). But for the youngest cohort—aged between 23 and 30—earnings increased. Second, earnings start to decline at a younger age over time. If age is a proxy for work experience, this means that, among older workers, the return to education and the return to experience are falling. This could be evidence of an accelerated skills obsolescence.

Source: WDR 2016 team, based on Campos-Vazquez, Lopez-Calva, and Lustig, forthcoming.

Box 2.10 Digital technologies and economic opportunities: A gender lens

Digital technologies can empower women economically and socially. Because social norms and time and mobility constraints are often more severe for women than for men, women could benefit greatly from technology.[a]

Digital technologies can reduce gender gaps in labor force participation by making work arrangements more flexible, connecting women to work, and generating new opportunities in online work, e-commerce, and the sharing economy. In Elance, a platform for online work now part of Upwork, 44 percent of workers are women, compared to an average of 25 percent in the nonagricultural economy globally. Business process outsourcing in India employs more than 3.1 million workers, 30 percent of them women. Four in ten online shop owners on Alibaba are women. Moreover, technology can help improve women's access and accumulation of productive assets. The digitization of land registries, for example, can be particularly beneficial for women.[b] These improved opportunities, in turn, can increase investments in young girls' human capital.[c]

Technology-driven shifts in skills demand can reduce wage gaps, especially among the better educated. Women are well positioned to gain from a shift in employment toward nonroutine occupations, and away from physical work.[d] In Germany and the United States, the use of digital technologies at work explains a significant share of the increase in female labor force participation and employment in the past few decades.[e] Similar changes have taken place in Brazil, Mexico, and Thailand, and also explain a large part of the reduction in gender wage gaps.[f] New technologies level the playing field, particularly among the better educated, who take on jobs that use their comparative advantage in nonphysical work.[g] Recent evidence from the United States shows that it is the better educated and women who are able to get the high-paying jobs intensive in nonroutine skills as middle-skilled jobs shrink.[h]

Digital technologies also impact women's voice and agency. Increased access to information can affect gender norms and affect aspirations, often faster than expected.[i] Social media is an additional outlet for women to participate in public discussions and voice their opinions (spotlight 3). "My Dress, My Choice" in Kenya, a social media movement against female violence that mobilized thousands of Kenyans, including through street protests, eventually led to changes in relevant laws.[j] Some of the new innovations of the digital economy, such as digital payments, mobile money, and taxi sharing rides, can also increase women's agency and control over economic resources, and their safety. For example, in Niger, greater privacy and control of mobile transfers, compared to manual cash transfers, shifted intrahousehold decision making in favor of women, the recipients of the transfer.[k]

But in many countries, gender gaps in technology use, and in working in the ICT sector, remain vast. Over 1.7 billion women in low- and middle-income countries do not own mobile phones. Women in those countries are 14 percent less likely to own a mobile phone than men, on average. Women in South Asia are 38 percent less likely to own a phone than men.[l] Barriers to access can be particularly salient in the case of the internet, especially in poor and remote localities where access is predominantly outside the home, and where social norms for socializing or safety concerns can become a barrier.[m] In Africa, for example, women are 50 percent less likely to use the internet than men.[n] In addition to ownership and access, lack of control over the use of the technology can be an additional barrier for women. In the Arab Republic of Egypt and in India, for example, 12 percent of women stated that they did not access the internet more often because they did not think it was appropriate, and more than 8 percent did not access it more often because family or friends would disapprove.[o] In the labor market, women are also much less likely to work in the information and communication technology (ICT) sector or in ICT occupations, which are well paid. These latter gaps partly reflect women's low participation in science, technology, engineering, and math (STEM) education, itself a product of early gender-based biases in formal and informal education (chapter 5).

Even with gender parity in ownership, access, and control over digital technologies, gains are not automatic. They need to be complemented with analog changes that address the underlying barriers to women's employment, voice, and agency. In rural South Africa, for example, mobile phones increased employment mostly among women, as long as they did not have large child care responsibilities.[p] In addition, technologies can have gender-differentiated effects, as shown throughout this chapter. This suggests that interventions around digital technologies would become more effective if they were more gender-informed, including by having women participate early on in the design of interventions and of the technologies themselves.

Moreover, by circumventing, rather than eliminating, some of the barriers to employability faced by women,

(Box continues next page)

Box 2.10 Digital technologies and economic opportunities: A gender lens *(continued)*

the internet could actually delay necessary reforms. For example, home-based work could help connect women to work in environments where social norms or child care responsibilities are a barrier to women working outside the home. But if working outside the home continues to be seen as unacceptable for women or if there is no availability of affordable child care, technology could end up delaying fundamental reforms. Addressing these underlying constraints remains key to the gender and overall economic agenda.

a. World Bank 2011.
b. World Bank 2014b. In Rwanda, the Land Tenure Regularization Programme demarcated and digitized 10 million plots. Households that registered their land were more likely to invest in it, and this effect was twice as strong for female-headed households (Ali, Deininger, and Goldstein 2014).
c. Oster and Millett 2013.
d. Rendall 2010; Weiberg 2000.
e. Black and Spitz-Oener 2007; Rendall 2010; Weiberg 2000.
f. Rendall 2010; Autor and Price 2013; Black and Spitz-Oener 2007.
g. WDR 2016 team, based on STEP household surveys (World Bank, various years).
h. Cortes and others 2014.
i. La Ferrara, Chong, and Duryea 2012; Jensen and Oster 2009.
j. Seol and Santos 2015.
k. Aker and others 2014.
l. GSMA 2015.
m. Gomez (2014) shows, for developing countries, that women—unlike men—prefer using the internet in public libraries rather than in private cybercafés because they are safer and despite poorer service.
n. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
o. Intel and Dalberg Global Development Advisors 2012.
p. Klonner and Nolen 2010.

better-paying jobs, skills need to be upgraded. Current and future workers need to develop the lifelong cognitive, technical, and socioemotional skills required of a well-educated worker in the 21st century. Workers also need to be capable of processing the ever-increasing information available on the internet. Building these skills requires actions affecting all relevant environments for learning: families, schools, universities, training systems, and firms. Given the speed of technological changes, these skills will also require constant updating throughout the life cycle as workers prepare for careers that last more than one job. Digital technologies themselves can help (sector focus 2 and chapter 5). Complementary reforms are also needed in tax policy, social protection, and labor market institutions to facilitate the transition of workers from old economy jobs to new economy jobs, and address the distributional consequences of the digital revolution.

Notes

1. World Bank 2014c.
2. Throughout this chapter, "opportunities" refer to people's short- and long-term capacity to generate income (Bussolo and Calva 2014). In addition, and taking a wide perspective, it is also used to include gains to consumers.
3. WDR 2016 team, based on STEP surveys (World Bank, various years); Central Asia World Bank Skills surveys (World Bank, various years); Survey-based Harmonized Indicators Program (SHIP) (World Bank, various years); Socio-Economic Database for Latin America and the Caribbean (SEDLAC) (CEDLAS and the World Bank); South Asia Region MicroDatabase (SARMD) (World Bank, various years); Europe and Central Asia Poverty (ECAPOV) Database (various years); East Asia Pacific Poverty (EAPPOV) Database (World Bank, various years); the I2D2 dataset (International Income Distribution Database) (World Bank, various years); ILO Laborsta database (ILO, various years); and the National Bureau of Statistics of China (various years). Automation probabilities adapted from Frey and Osborne (2013).
4. WDR 2016 team calculations, based on ILO Key Indicators of the Labour Market (KILM; various years), ILO Laborsta database (various years), World Bank's International Income Distribution Database (I2D2; various years), and the National Bureau of Statistics of China (various years). For more details, see figure 2.15.
5. WDR 2016 team calculations, based on World Development Indicators (World Bank, various years).

6. ITU's (International Telecommunication Union) World Telecommunication/ICT Indicators (ITU, various years), Gallup World Poll, and Eurostat Information Society Statistics (EC 2015).
7. This, like the rest of the chapter, is based on household survey data. Subscription data, often based on estimates, are widely available but have upward and downward biases. Although less readily available, household surveys can better account for sharing of mobile phones, or for one individual having more than one subscription or phone.
8. Handel 2015, for WDR 2016; Aker 2010b.
9. WDR 2016 team, based on Research ICT Africa surveys (various years).
10. Veeraraghavan, Yasodhar, and Toyama 2009.
11. WDR 2016 team, based on the Argentina National Institute of Statistics and Census, Brazilian Internet Steering Committee, Colombia Directorate of Statistical Methodology and Production, European Commission Eurostat database (various years), Mexico National Institute of Statistics and Geography, and Uruguay National Institute of Statistics.
12. Eurostat (EC, various years), for the WDR 2016.
13. WDR 2016 team, based on Brazilian Internet Steering Committee and Mexico National Institute of Statistics and Geography.
14. WDR 2016 team, based on Research ICT Africa surveys (various years).
15. WDR 2016 team, based on Brazilian Internet Steering Committee and Mexico National Institute of Statistics and Geography.
16. WDR 2016 team, based on Gallup World Poll, various years.
17. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
18. ICT surveys for Argentina, Brazil, Colombia, Mexico, and Uruguay; and Eurostat (EC, various years).
19. WDR 2016 team calculations, based on Research ICT Africa surveys (various years).
20. Gomez 2014.
21. Ritter and Guerrero 2014.
22. Galperin and Viecens 2014; Pimienta, Prado, and Blanco 2009.
23. De los Rios 2010.
24. Atasoy 2013.
25. Ritter and Guerrero 2014.
26. Klonner and Nolen 2010.
27. OECD Key Economic Indicators Database, latest year available (circa 2011).
28. Berger and Frey 2014.
29. Brynjolfsson and McAfee 2014.
30. WDR 2016 team, based on STEP household surveys (World Bank, various years).
31. WDR 2016 team, based on STEP household surveys (World Bank, various years).
32. Moretti and Thulin 2013 for the United States; Maloney and Valencia 2015 for Turkey.
33. CGAP 2014.
34. Fernandes and others 2015.
35. Dutz and others 2015, for the WDR 2016.
36. Gaggl and Wright 2014.
37. Akerman, Gaarder, and Mogstad 2015.
38. Blinder and Krueger 2013.
39. Kennedy and others 2013.
40. NASSCOM 2014.
41. Jensen 2012.
42. IBM 2014.
43. See http://elance-odesk.com/online-work-report-global, accessed October 2, 2014.
44. Agrawal and others 2013.
45. Heeks and Arun 2010; Kennedy and others 2013; Monitor Inclusive Markets 2011.
46. Samasource 2015. Digital Divide Data has more than 1,300 employees, with 10 percent of its data management operators having physical disabilities (Digital Divide Data 2014). Ruralshores is active in remote rural areas in India and has 2,500 employees (http://ruralshores.com/about.html).
47. Imaizumi and Santos, forthcoming.
48. China Association for Employment Research 2014.
49. Schaefer-Davis 2005.
50. See https://www.etsy.com/about/?ref=ftr, accessed May 15, 2015.
51. Based on an online survey of 60 countries worldwide done by Nielsen in 2013 (Van Welsum 2015).
52. See https://www.airbnb.com/about/about-us, accessed March 11, 2015.
53. See http://www.gravitytank.com/pdfs/info_graphics/SharingEconomy_web.pdf, as cited in Van Welsum 2015.
54. In a study of Uber in the United States, Hall and Krueger (2015) show that drivers aged 18–29 years are 19 percent of all Uber drivers, compared to 8.5 percent among regular taxi drivers and chauffeurs. Female drivers are 13.8 percent of Uber drivers, compared to 8 percent elsewhere. At the same time, however, Uber drivers are less likely than traditional employees to have health insurance, and half leave Uber within 50 weeks.
55. Montenegro and Patrinos 2014.
56. Bagues and Sylos 2009; Nakamura and others 2009; Stevenson 2009.
57. See http://press.linkedin.com/.
58. WDR 2016 team, based on STEP household surveys (World Bank, various years).
59. Kuhn 2014; Raja and others 2013.
60. Dammert, Galdo, and Galdo 2014.
61. Mang 2012.
62. Kuhn 2014; Kroft and Pope 2014.
63. Kuhn and Mansour 2014.
64. Imaizumi and Santos, forthcoming, for the WDR 2016.
65. Arias and others 2014.
66. OECD 2011.

67. World Bank 2011.
68. See http://blog.jetblue.com/index.php/2013/09/05/unpacked-working-from-home/, accessed June 19, 2015.
69. Bloom and others 2014.
70. See http://www.philstar.com/education-and-home/2013/06/13/953332/filipino-teachers-uruguay.
71. Muto and Yamano 2009.
72. e-Choupal, "The Status of Execution." http://www.itcportal.com/businesses/agri-business/e-choupal.aspx.
73. World Bank 2014a; Demirgüç-Kunt and others 2015.
74. Jack and Suri 2014.
75. Fingerprint scanning among paprika farmers in Malawi increased repayment rates (IFPRI and World Bank 2010).
76. For a discussion on personal networks and labor markets, see Granovetter (1973) and Calvo-Armengol (2004).
77. Boase and others 2006.
78. World Bank 2011.
79. La Ferrara, Chong, and Duryea 2012; Jensen and Oster 2009.
80. WDR 2016 team, based on Research ICT Africa surveys (various years).
81. De, Mohapatra, and Plaza, forthcoming, for the WDR 2016.
82. Camacho and Conover 2011; Jensen 2010.
83. Goyal 2010; Aker 2010a; Best and others 2010; Aker 2011; Martin 2010.
84. Aker and Mbiti 2010.
85. Beuermann, McKelvey, and Vakis 2012.
86. May, Dutton, and Munyakazi 2011.
87. Jensen 2007.
88. Pineda, Aguero, and Espinoza 2011.
89. Galiani and Jaitman 2010.
90. Asad 2014.
91. Aker 2010a; Pineda, Aguero, and Espinoza 2011.
92. Aker 2010a.
93. Aker 2011.
94. Tadesse and Bahiigwa 2015; Jagun, Heeks, and Whalley 2008.
95. Amazon Mechanical Turk is an online work platform. The quote was obtained through an online questionnaire of online workers done in September 2014 for this Report.
96. Varian 2011.
97. Government of Estonia 2015.
98. Interactive Advertising Bureau 2010.
99. Greenstein and McDevitt 2011.
100. WDR 2016 team, based on Research ICT Africa surveys (various years).
101. Pew Research Center 2014.
102. In the United States, the median tenure for male wage and salary workers was lower in 2014 at 5.5 years, compared with 5.9 years in 1983 (Copeland 2015). Dutz and others (2015, for the WDR 2016) show more turnover among young workers in industries intensive in ICT in Brazil. See also Stevenson 2009.
103. Handel 2015, for the WDR 2016.
104. World Bank 2012, 2013.
105. Forman, Goldfarb, and Greenstein 2012.
106. Eden and Gaggl 2014; Karabarbounis and Neiman 2013. Eden and Gaggl (2015, for the WDR 2016) suggest that while the fall in the routine share of labor is linked to technological change, the shift in the labor share compared with that of capital may be a more complex story. In the United States, housing prices have been identified as a key driver in the rise of capital shares (Bonnet and others 2014). This chapter focuses on the fall of routine labor within the labor share, as this is more clearly linked to technological change.
107. From 16 to 14 percent in the case of Honduras, and from 18 to 16 percent in the case of Romania (Eden and Gaggl 2015, for the WDR 2016).
108. Acemoglu 2002; Aghion and others 2015; Dabla-Norris and others 2015; Garicano and Rossi-Hansberg 2006; Jaumotte, Lall, and Papageorgiou 2008; Autor, Katz, and Krueger 1998.
109. Acemoglu and Autor 2011; Akcomak, Kok, and Rojas-Romagosa 2013; Autor and Dorn 2013; Goos, Manning, and Salomons, forthcoming.
110. Autor, Dorn, and Hanson, forthcoming; Autor, Dorn, and Hanson 2013.
111. The number of workers in agriculture declined in China between 2000 and 2010, but the number of workers within the sector that were machine or equipment operators almost doubled (WDR 2016 team, based on the National Bureau of Statistics of China, various years).
112. Dutz and others 2015; Messina, Oviedo, and Pica 2015 for Mexico and Peru.
113. Goldin and Katz (2008) refer to a race between education and technology when discussing the case of the United States, but the phrase was first used by Tinbergen (1975).
114. Brynjolfsson and McAfee (2014, 11).
115. Oviedo and others (forthcoming) use STEP household surveys (World Bank, various years) from 10 developing countries to characterize the typical tasks done across occupations, and show that, indeed, occupations that are considered intensive in nonroutine cognitive and socioemotional skills require workers to do more complex reading, write longer texts, use more advanced math, contact more clients, collaborate more with others, as well as do more thinking, learning, supervising, and presenting. By contrast, these occupations do fewer routine and manual activities, such as operating machines and doing physical activities.
116. WDR calculations based on STEP household surveys (World Bank, various years).

117. This is referred to as functional literacy. *Functional illiteracy* is defined as the proportion of exam takers (15-year-olds) who score below a level 2 on the Programme for International Student Assessment (PISA) reading test (WDR 2016 team, based on OECD PISA 2012 scores).
118. World Bank 2014c.
119. WDR 2016 team, based on Research ICT Africa (various years). Among those who do not cite a lack of connection as a reason for not using the internet, 3 out of 10 say they do not use the internet because they do not know how to.
120. PIAAC survey.
121. World Bank 2010.
122. Valerio and others, forthcoming. Most of this literature remains focused on the returns to computer use (Spitz-Oener 2008; Sakellariou and Patrinos 2003). Most studies are not based on random assignment of the technology, and estimates likely reflect that these workers have other characteristics or skills that command an earnings premium. In a randomized experiment using fictitious resumes for white-collar occupations in Buenos Aires and Bogota, ICT skills increased the probability of receiving a job callback by one percentage point (Lopez-Boo and Blanco 2010).
123. Correa and de Sousa 2015, for the WDR 2016.
124. Akerman, Gaarder, and Mogstad 2015.
125. Cunningham and Villasenor 2014.
126. Valerio and others 2015a, 2015b; Ajwad and others 2014a; Ajwad and others 2014b; Bodewig and others 2014.
127. Valerio and others 2015a; Valerio and others 2015b.
128. Eden and Gaggl 2015, for the WDR 2016.
129. For example, it is often difficult to distinguish between trade and technology (chapter 1).
130. Akcomak, Kok, and Rojas-Romagosa 2013; Autor, Dorn, and Hanson, forthcoming; Eden and Gaggl 2014; Karabarbounis and Neiman 2013; Michaels, Natraj, and Van Reenen 2014.
131. WDR 2016 team, based on I2D2 data (World Bank, various years).
132. Autor 2014; Autor and Dorn 2013; Autor, Levy, and Murnane 2003; Spitz-Oener 2008; MacCrory and others 2014.
133. Autor 2014; Summers 2014; Brynjolfsson and McAfee 2014.
134. Ryder 2015.
135. Autor, Dorn, and Hanson, forthcoming.
136. Statista 2015.
137. World Bank team under the Government Financial Management and Revenue Administration Project. Other regulatory and business processes changes also help explain the redundancy of workers.
138. WDR 2016 team interview with Dr. Ishrat Hussain, former governor of the State Bank of Pakistan, January 30, 2015.
139. Bowles 2014; Frey and Osborne 2013.
140. Autor, Dorn, and Hanson, forthcoming. Their analysis examines the period between 1980 and 2007.
141. Autor 2014.
142. Handel 2000.
143. Gaggl and Wright 2014.
144. Jaimovich and Siu 2012.
145. Handel 2015, for the WDR 2016.
146. Luddites were English textile workers who protested rapid automation in the early 19th century by destroying the machinery used to replace them.
147. Crafts 2015, for the WDR 2016; Katz and Margo 2013; Gray 2013.
148. MacCrory and others 2014.
149. Crafts 2015, for the WDR 2016.
150. For a discussion on “premature” deindustrialization, see Rodrik 2015.
151. Turner 2014.
152. Berger and Frey 2014.
153. Beaudry, Green, and Sand 2014.
154. Crafts 2015, for the WDR 2016.
155. Brynjolfsson and McAfee 2014.
156. Countries in Europe and Central Asia are a case in point. Starting from a comparable institutional and economic level in the early 1990s, countries that carried out the most economic reforms (for example, the Czech Republic, Estonia, and Poland) have seen a more rapid shift toward new economy occupations (Arias and others 2014). Historically, GDP per capita has also been a strong determinant of technology adoption (Crafts 2015).
157. Autor 2014.
158. WDR 2016 team, based on STEP household surveys (World Bank, various years).
159. Acemoglu and Autor 2011; Aedo and others 2013; Arias and others 2014; Autor and Price 2013; Autor, Levy, and Murnane 2003; Bruns, Evans, and Luque 2012.
160. Cortes and others 2014.
161. Skirbekk 2013.
162. Skirbekk 2013.

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