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Unlocking the potential of knowledge and technology for all

CONTENTS

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1 Introduction: Unlocking the potential of knowledge and technology for all

Knowledge and technology have spread around the world as societies and economies become increasingly interconnected. As globalization of technology, of trade, of finance and of people are interrelated and mutually reinforcing, it is easy to imagine examples whereby technology enabled greater trade and finance, where trade led to the diffusion of technologies and demand for finance, where finance has enabled trade and technological progress, and where movement of people led to knowledge spillovers.

The rapid diffusion of technology around the world has brought extraordinary benefits to many people who would otherwise have limited access to innovations in communication, production, health, education, and many others. Access to knowledge and technology have contributed to solutions for environmental, social, and economic problems. From opening new options for renewable energy, to revolutionizing the delivery of government services, improving health care, and creating new jobs, technology impacts almost everyone's lives.

But the access to technology and innovation has been uneven. While some have access to advanced technologies, including the latest developments in science, engineering, healthcare, and others, many are still lacking access to technologies that were invented decades ago. There is a growing gap between developed and developing countries in how much recent technologies are used. This has accentuated the division between countries, in particular it has increased the difference between those in the frontier of technological advancements (core) and those lagging behind (periphery).

To achieve the potential of technology while leaving no one behind, it is important to achieve greater diffusion and adoption of technology in areas where it can have great impact. The number of people lacking access to even basic technologies like electricity and basic water and sanitation systems, for example, illustrates the challenge of diffusion. Advanced technologies can unlock large productivity gains for those that can use them, and widen the gap with those that cannot. The multilateral system has an important role to play in promoting and facilitating technological diffusion.

At the same time, some technologies involve trade-offs or have unintended consequences. Automation enabled by technology creates winners and losers. There is a concern, for example, that technology will lead to a mass replacement of workers. Understanding these issues require institutional approaches to ensure that the path towards the 2030 objectives is not undermined by the negative effects of technological progress. The multilateral system has a central role in supporting national efforts.

2 Trends in the development and diffusion of technology

This section will review trends in globalization of technology as it relates to a) global generation of innovation and knowledge creation and b) global diffusion of technology and innovations.

In terms of global generation of innovation and knowledge creation, this section will look at trends in research and development (R&D) and patents, as well as increased global collaboration in terms of scientific research. The section will show that, although there is a trend towards a more multipolar world, innovation and knowledge creation are still driven by and concentrated around a few countries.

In terms of global technology diffusion, this section will look at the long-term pattern of technology diffusion and adoption of various inventions. The section will present trends in the diffusion and use of basic technology and ICT technology as well as more current frontier technologies.

A. Globalized innovation and knowledge creation

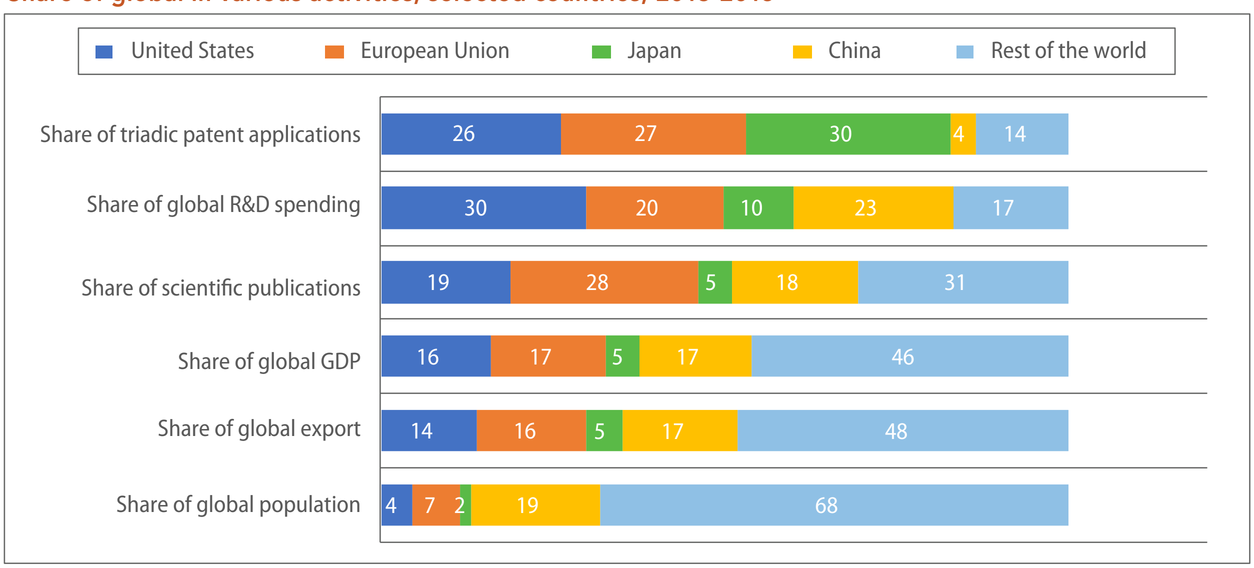
In recent years, there has been a trend towards more globalization of innovation and knowledge creation. More and more countries are investing in R&D and developing capacity for scientific research. However, most innovation still takes place in a few countries and most technologies are initially developed in developed countries.[1] World Bank finds that the intensity of innovation is closely related to per capita income, and that most developing countries lack the ability to generate innovations at the technological frontier.[2]

Activities related to generation innovation and knowledge creation are more concentrated than other global activities. In terms of triadic patent application, United States, EU-28, Japan and China represented 86 per cent of application. In terms of R&D spending and share of scientific publications, these economies represent 83 per cent and 69 per cent, respectively. These shares are notably larger than the share of the same economies in global trade, global GDP and global population (figure 1).

Research & development

In terms of research and development (R&D), global investment has continued its fast growth, but there are large disparities among regions. Since 2000, total (public and private) spending on R&D has had an average annual growth rate of 4.5 per cent.[3] United States remains the largest investor in R&D, accounting for 30 per cent of global R&D investment in 2014. Chinese R&D investment has grown remarkably over the past decades and it is now the second-largest performer in terms of R&D spending and accounts for 23 percent of total world R&D expenditure.[4] However, given recent trends in several other emerging economies, a more multipolar global research landscape is likely to emerge in the coming years.[5]

Figure 1
Share of global in various activities, selected countries, 2013-2015



Source: UNCTADStat, OECD, National Science Foundation (2016) and UN Population Division.

1 United Nations (2017), Financing for development: Progress and prospects, Report of the Inter-Agency Task Force on Financing for Development 2017.

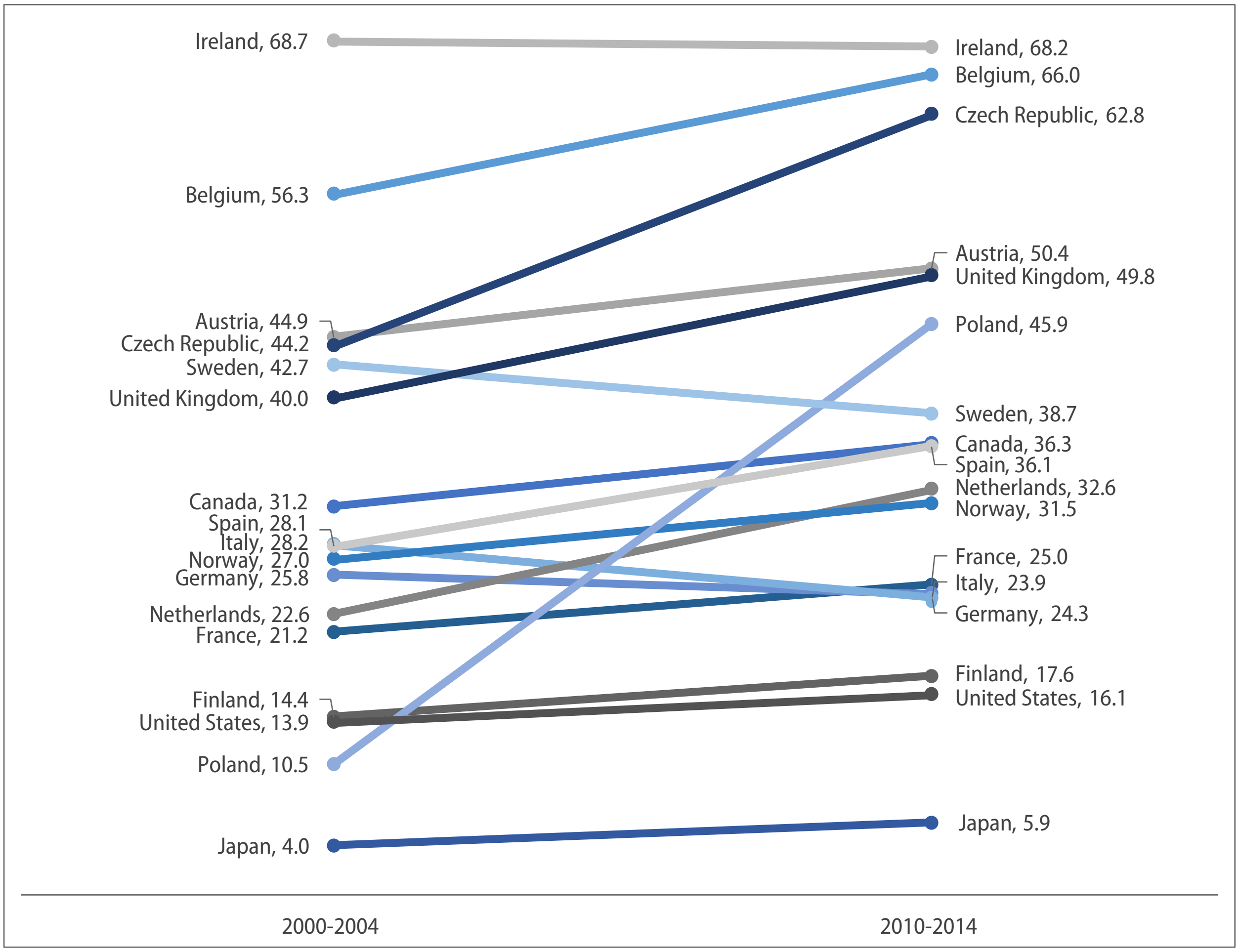
2 World Bank (2008), Global Economic Prospects 2008: Technology Diffusion in the Developing World. Global Economic Prospects and the Developing Countries (GEP). Washington, DC: World Bank.

3 United Nations (2017), The Sustainable Development Goals Report 2017.

4 OECD Main Science and Technology Indicators Database

5 OECD (2016), OECD Science, Technology and Innovation Outlook 2016, OECD Publishing, Paris. http://dx.doi.org/10.1787/sti_in_outlook-2016-en

Figure 2
R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises



Source: OECD Main Science and Technology Indicators Database.

A specific manifestation of globalization of R&D and innovation is the trend that companies are performing their R&D through their international branches. One indicator of this is the share of R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises. For most countries, the share of R&D by foreign affiliates accounts for more than 20 percent. In a few countries, the majority R&D spending of enterprises is conducted by foreign affiliates and this share has increased over the last decade in most OECD countries (figure 2).

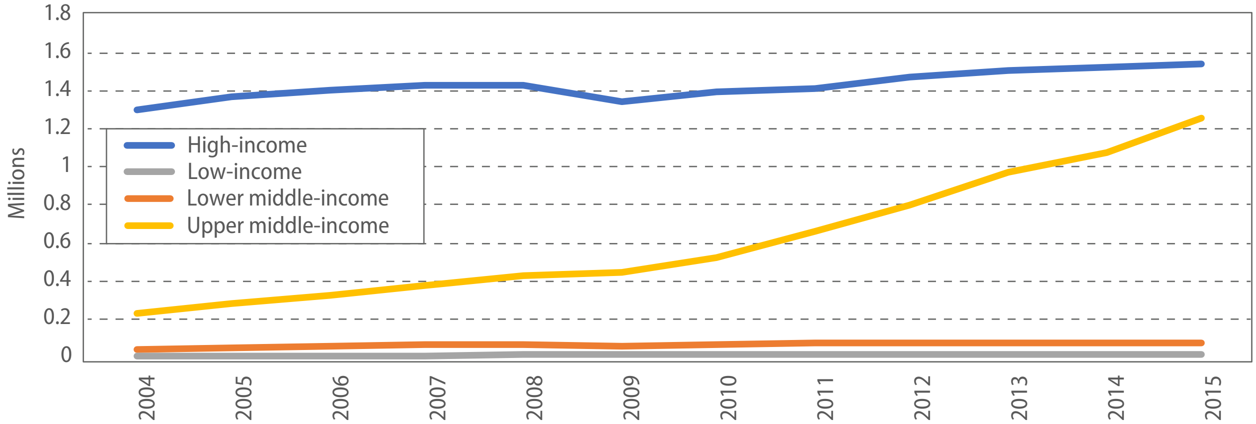
Patents and scientific research

Patent statistics are another relevant available measure for examining global collaboration of technology. While the total number of patent applications has exploded in recent years, doubling from 1.5 million in 2004 to 2.8 million in 2015, patent applications are still heavily dominated by high-income countries. The most important trend in recent years, however, is the rapid rise in the number of Chinese patent applications (figure 3).

Patented inventions are often the result of collaboration between inventors from different countries. On average, the international co-invention of patents increased by 27 per cent between 2000-03 and 2010-13.[6] However, global patent networks have remained over time, centered around the United

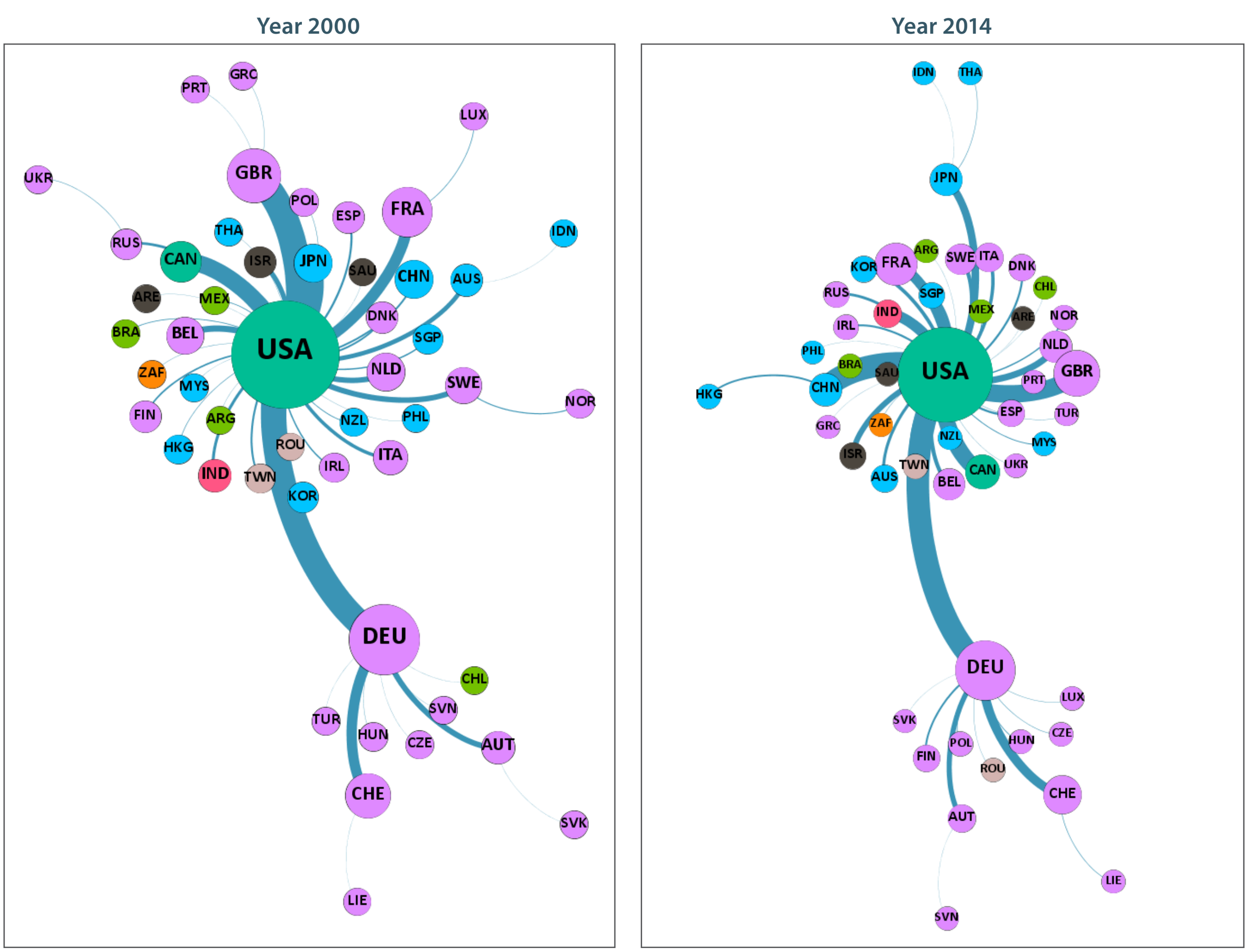
6 OECD (2015), OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society, October.

Figure 3
Total patent applications (direct and PCT national phase entries), by income group



Source: WIPO.

Figure 4
Network visualization of patents with foreign co-investors



Source: Staff elaborations based on OECD Patent Statistics.

Notes: For each network chart, only the top 50 economies and their most important partner economy (all in terms of number of patents applications) are included. The size of each node denotes the total number of patent applications. The nodes are color-coded based on region. The thickness of each edge indicates the relative number of patents applications with foreign co-inventors between two countries.

States. This indicates that the network of patent collaboration has a core-peripheral structure rather than a cluster structure, in contrast, for example, to the current global trade network (figure 4).

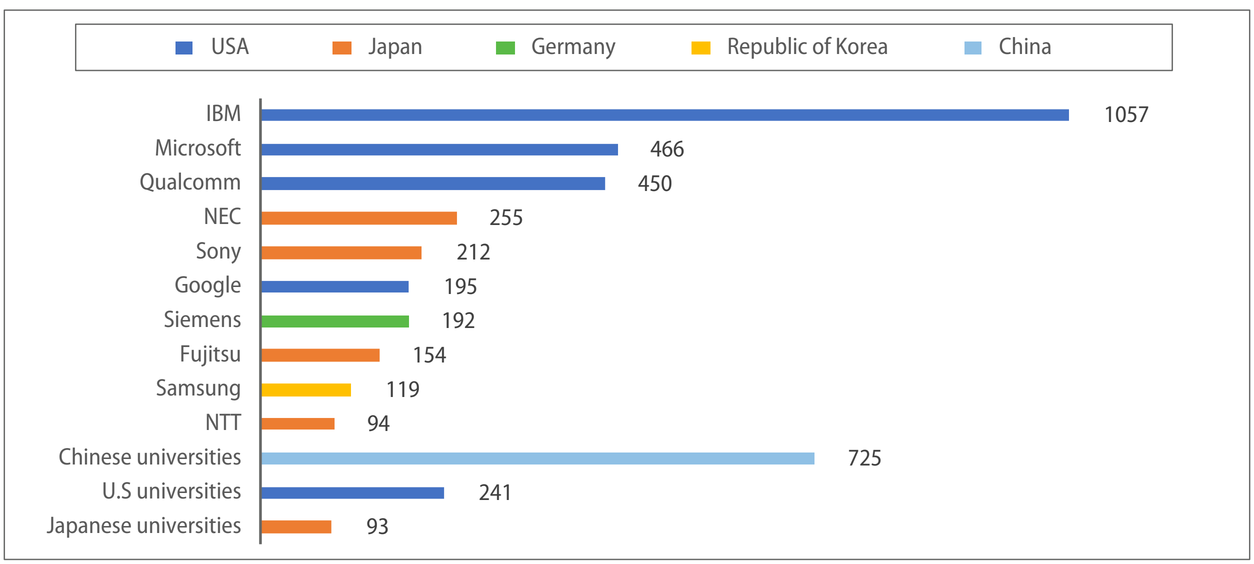
The global importance of Artificial Intelligence (AI) technology has been growing in recent years. Research shows how a few technology giants remain by far the world's dominant patent applicants, which limits global diffusion (figure 5).[7] Trends in where AI is being done internationally can also be seen in application country of patents and the institutional affiliation of researchers. The number of AI patents granted has increased more than threefold, from 708 items in 2012 to 2,888 items in 2016. AI patents granted in the United States increased by 1,628 items during this period, which represents approximately 75 per cent of the AI patent increase worldwide.

Another aspect of globalization of technology and knowledge is manifested in the globalization of scientific research. Scientific research is increasingly global and is occurring in more and more places than before. The traditional 'scientific superpowers', United States, Western Europe and Japan, still lead the field, but rapid developments are taking place in many developing and emerging economies.

This is especially the case for so-called frontier technologies. Regarding research related to Artificial Intelligence (AI) the dominance of United States is clear. For example, this is manifested when considering the institutional affiliation of all authors of papers presented at a major AI research conference, namely, the Association for the Advancement of Artificial Intelligence (AAAI) Conference on Artificial Intelligence. In 2012, 41 per cent of authors were from US institutions, but by 2017 this was down to 34 per cent, while the share of participants from Chinese institutions jumped from 10 per cent in 2012 to 24 per cent in 2017.[8]

The scientific world is also becoming increasingly interconnected, with international collaboration on the rise. The percentage of publications with authors from different countries rose from 13.2 per cent to

Figure 5
Number of AI patents granted, 2010 to 2016



Source: Fujii, H, and S Managi (2017).

7 Fujii, H, and S Managi (2017), Trends and Priority Shifts in Artificial Intelligence Technology Invention: A global patent analysis, RIETI Discussion Paper Series 17-E-066.

8 Goldfarb A, and Trefler D (2017), AI and Trade, Papers presented at NBER conference on AI and Economics, 13-14 September, 2017, Toronto.

19.2 per cent between 2000 and 2013.[9] This is the result of the increasing global capabilities in R&D, a larger number of trained researchers globally and improvements in communication technology. However, collaboration between developing countries is still minimal, and while links between the large emerging economies (Brazil, Russia, India and China) have grown in recent years, they remain small in comparison to the volume of collaboration between these individual countries and G7 countries.[10]

B. Global diffusion of technology

Given the dominant role of a few countries in innovation and knowledge creation, discussed above, technological globalization is driven in large part by technological diffusion, i.e. the spread of technology across borders.[11] The mobile phones and the internet have reached developing countries much faster than previous technological innovations. More households in developing countries own a mobile phone than have access to electricity or improved sanitation.

New technologies spread to other countries at an increasing speed, but the intensity of use of these technologies in developing countries is not keeping pace.

Considering 25 different invention in the last 200 years, Comin and Hobijn[12] explored whether there has been any trend in adoption lags.[13] They find that new technologies have diffused on average faster and that adoption lags have converged across countries. Recent technologies such as cell-phone or internet have arrived within very few years to both developed and developing countries. For example, while it took over 120 years for the steam engine to make its way from the United Kingdom to Indonesia, it took only 11 years after the invention of the computer for it to be adopted in Vietnam. As is clear from figure 6, the average adoption lags have decreased over time. This trend can be observed for the last two centuries, but the recent wave of globalization and the digital revolution has contributed to the acceleration in diffusion of technologies in recent decades.

While adoption lags of new technologies have converged across countries, developing countries struggle to employ these technologies with the same degree of intensity and versatility as developed countries. While technologies such as spindles were utilised similarly in developed and developing countries, newer technologies have been relatively less utilized in developed countries. Hence, the intensity of technology adoption between rich and poor countries is larger for newer than for old technologies, which indicates that the time it takes for a technology to become widespread after adoption has diverged over the last 200 years. The magnitudes of this divergence are very significant. For example, the intensity of use of the internet in the median developing country has been approximately one-third that of the median developed country. This suggests that despite all the great uses found in developing countries for some new technologies, in developed countries they have found even more uses.[14]

9 National Science Board (2016), Science and Engineering Indicators 2016. Arlington, VA: National Science Foundation (NSB-2016-1).

10 Wilsdon, James and et al, (2011) *Knowledge, networks and nations: global scientific collaboration in the 21st century.* The Royal Society, London.

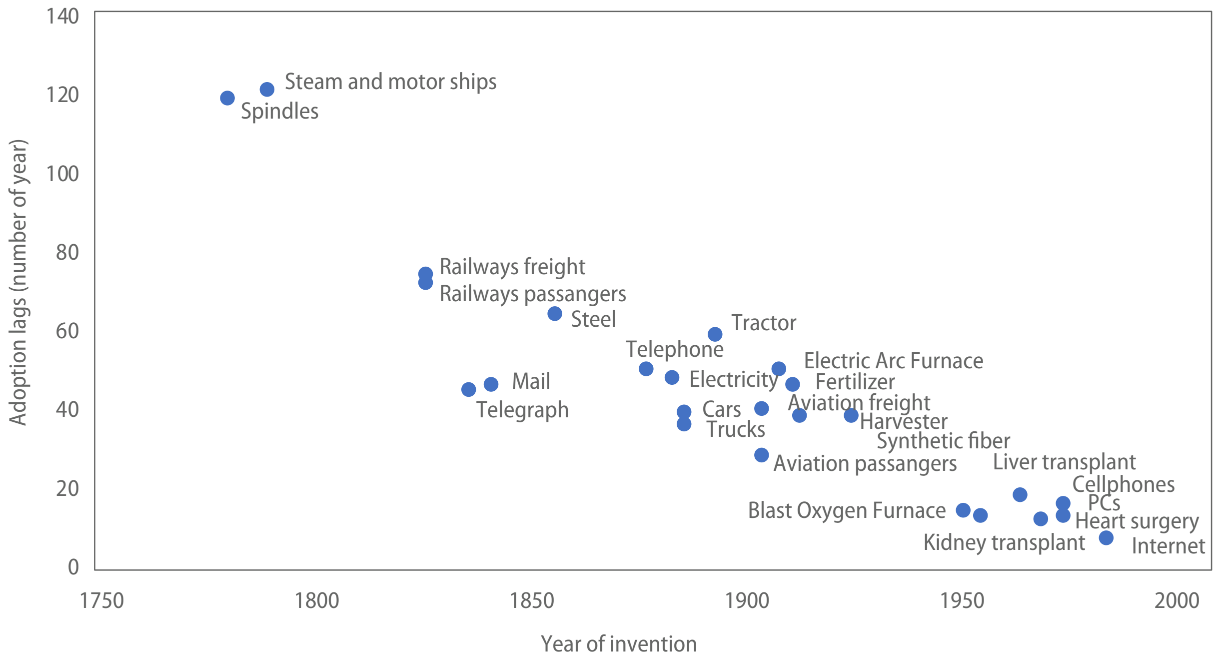
11 Measuring the diffusion of technology has been historically a very challenging undertaking. Traditional measures require micro-level data, limiting their coverage to narrow applications. In the absence of micro-level data, country level data can be used to calculate the intensity of use of technologies (how many people and how often). See the CHAT dataset: www.nber.org/papers/w15319.

12 Comin, Diego, and Bart Hobijn (2010), An Exploration of Technology Diffusion. American Economic Review, 100(5): 2031-59.

13 Adoption lag between two countries is defined as the number of years it has taken a country to reach the same usage intensity of a technology as another country.

14 Comin, Diego (2014), The Evolution of Technology Diffusion and the Great Divergence, paper for 2014 Brookings Blum Roundtable.

Figure 6
Adoption lags of new technologies, average number of years



Source: Comin, Diego, and Martí Mestieri Ferrer (2010), If Technology Has Arrived Everywhere, Why has Income Diverged? NBER Working Paper No. 19010.

Basic technology is still not fully diffused

Many basic technologies are recognized by the 2030 Agenda for sustainable development, such as access to energy, water and sanitation and clean cooking fuels and technologies. While there has been notable progress in these areas in recent decades, these basic technologies still have not been fully diffused and adopted in many developing countries (figure 7).

In 2014, 85.3 per cent of the global population had access to electricity, up from 77.6 per cent in 2000. However, this means that, 1.06 billion people globally still lived without this essential service. Around 80 per cent of them concentrated in just 20 countries. More than half the people without electricity lived in sub-Saharan Africa. The region had the lowest electrification rate overall at 37 per cent, but the figure is only 17 per cent in rural areas.

Three billion people still lack access to clean and safe cooking fuels and technologies, which causes many health hazards. From 2000 to 2014, the proportion of the global population with access to such fuels and technologies increased only from 50 per cent to 57 per cent, progressing much more slowly than electrification.

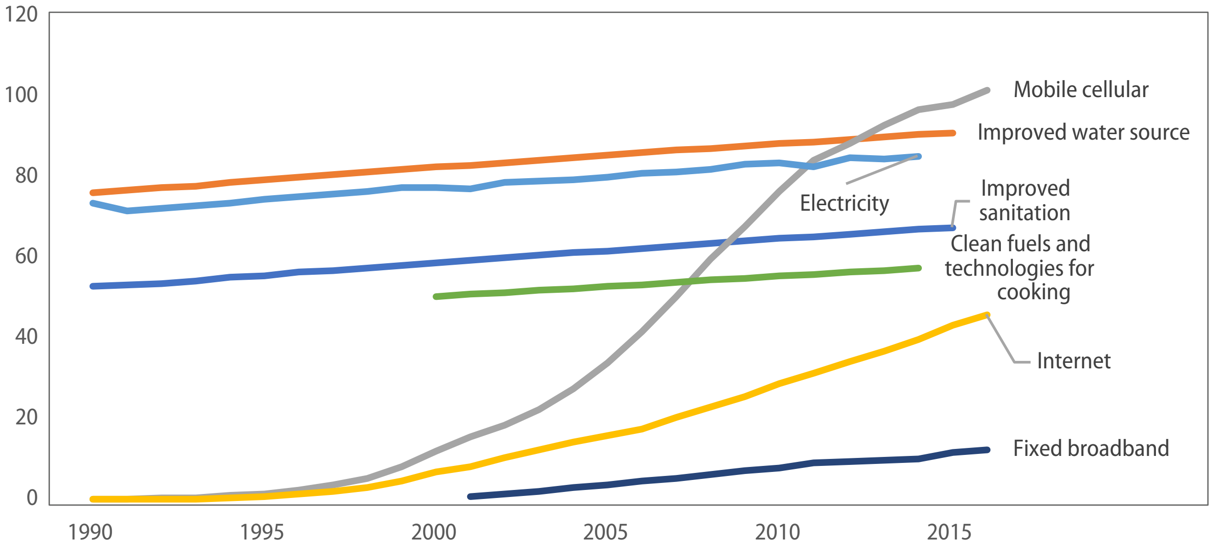
In 2015, only 71 per cent of the global population used an improved water source and 68 per cent of the global population used improved sanitation facilities. Despite a decrease in recent years, open defecation, which poses serious health risks, is still practised by 12 per cent of the global population in 2015.[15]

Rapid spread of ICT, but large differences between regions

The 2030 Agenda for sustainable development recognizes explicitly the potential of information and communications technology for global interconnectedness

15 United Nations (2017), The Sustainable Development Goals Report 2017.

Figure 7
Proportion of world population with access to various technologies



Source: World Bank World Development Indicators.

and to accelerate human progress. The rapid spread of ICT, seen in figure 7, has enabled people and businesses living in unconnected areas to join the global information society. In the last decade, mobile cellular services have spread at a rapid pace. By 2016, third-generation (3G) mobile coverage, which delivers higher speed access to the Internet and information and communication technology services, stood at 84 per cent globally. In LDCs, 52 per cent of people live in areas covered by a 3G signal.

Fixed-broadband services remain unavailable across large segments of the developing world. In 2016, fixed-broadband penetration reached 30 per cent in developed countries, but only 8.7 per cent and 0.9 per cent in developing regions and LDCs, respectively (figure 8a). However, the increased mobile coverage has contributed to a steady increase in the number of internet users in all regions. In the developed regions, 80 per cent of the population use the internet, compared to 39 per cent in developing regions and 15 per cent in LDCs (figure 8b). There are also large differences in who uses the Internet within countries. For example, in 2016, levels of Internet use worldwide were 12 per cent lower for women than for men; the gender gap remains even larger in LDCs at 31 per cent.[16]

Frontier technologies: Industrial robots

Based on data from the International Federation of Robotics (IFR), global sales volume of industrial robots has accelerated from an annual average of 5 per cent between 2005 and 2012 to 16 per cent per year between 2012 and 2016. However, a few countries account for around 75 per cent of the supply of robots in 2016. Notably, China has led the world in the supply of industrial robots. China's share in the global supply of robots have increased from 12 per cent in 2010 to 30 per cent in 2016. It is estimated that by 2020, 40 per cent of the global supply will come from China (figure 9).

16 United Nations (2017), The Sustainable Development Goals Report 2017.

Figure 8a
Fixed broadband subscriptions, per 100 inhabitants

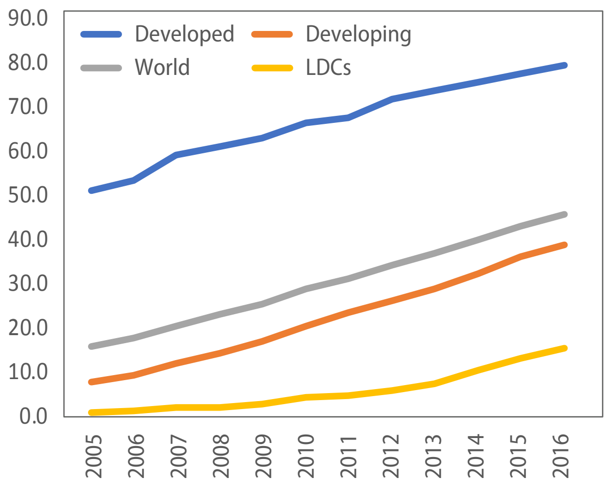
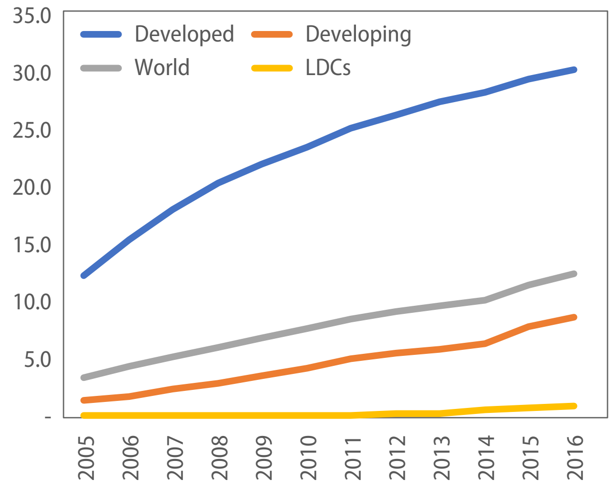
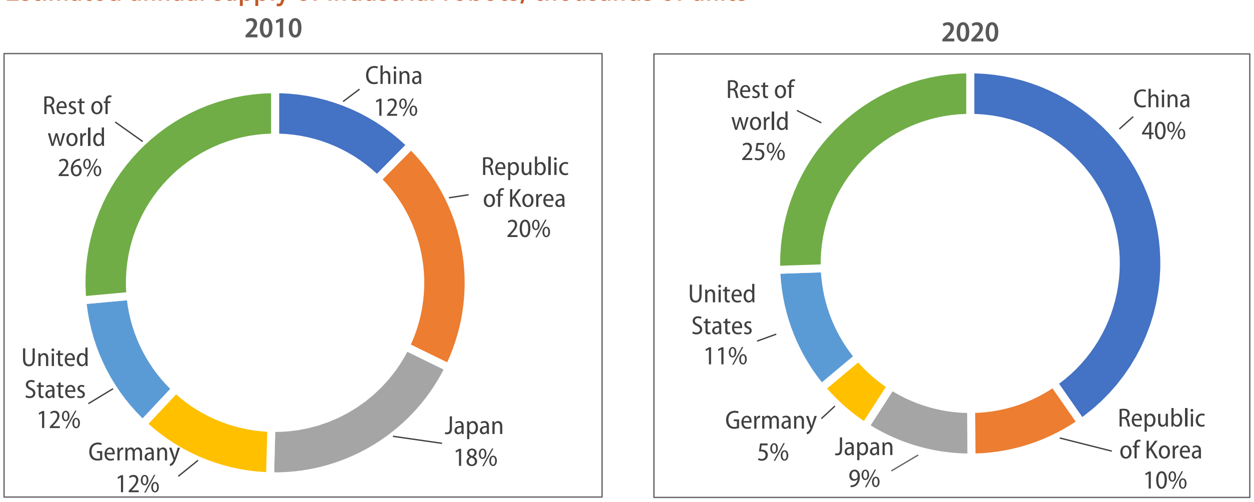


Figure 8b
Individuals using the Internet, per 100 inhabitants



Source: International Telecommunication Union (ITU).

Figure 9
Estimated annual supply of industrial robots, thousands of units

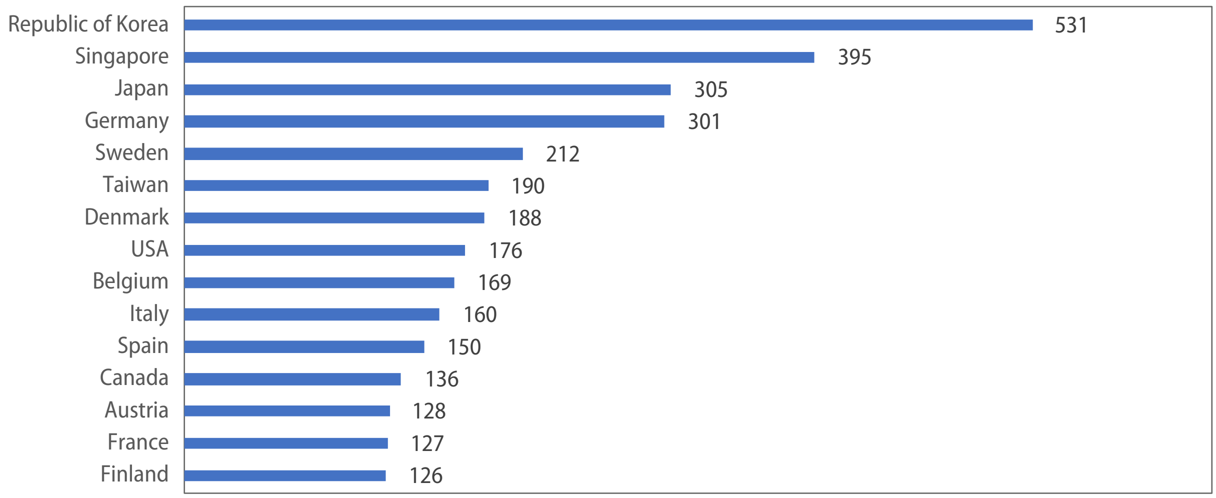


Source: IFR World Robotics 2017.

Robot density, the number of industrial robots in manufacturing per manufacturing employee, can be used as a proxy for overall industrial automation. This density is the highest in developed countries and developing countries at mature stages of industrialization (figure 10). Developing countries with the highest recorded robot density, are Thailand, which ranks twenty-fifth, Mexico, which ranks twenty-seventh, Malaysia, which ranks thirty-first and China, which ranks thirty-fifth.[17]

17 UNCTAD (2017), Trade and Development Report 2017: Beyond Austerity: Towards a global new deal.

Figure 10
Number of multipurpose industrial robots per 10,000 employees in manufacturing industry, 2015



Source: IFR World Robotics 2016.

3 Impacts of technological diffusion on sustainable development

Better access to existing and new technology holds the keys to achieving the vision of the 2030 agenda. Technology can lead to an energy revolution to combat climate change. It can unlock another agricultural revolution and help achieve food security. Technology can help make quality education accessible to all and revolutionize how students learn. It can catalyse civil society, promote social cohesion and improve the delivery of government services. On the economic side, technology has underpinned widespread growth and historic reductions in poverty. Eradicating poverty by 2030 and leaving no one behind will require that technology and its gains are shared by all.

A. Understanding the diffusion of technology

The diffusion of technological progress has mostly been incremental and gradual over time. New inventions must first prove their value before there is widespread use. On a few occasions, new inventions have combined with the right economic, social, and institutional conditions to allow for widespread diffusion. The adoption of steam to power machines, the discovery and use of electricity, and the ease of communication permitted by information and communication technologies (ICT) are examples of technologies that became widely used and that were at the center of the three great disruptive periods in modern economic history. Today we recognize these examples as industrial or technological revolutions and they ultimately transformed the organizational structure of societies and economies.

However, the diffusion of technologies often takes a long time, given that their adaptation requires complementary changes in physical infrastructure, institutional, social and organizational changes. The steam engine was only widely diffused once the combination of abundant energy and expensive labour made the technology more attractive for a growing number of industries. The speed of adoption and diffusion of technology in an economy depends on a wide range of factors, including maturity, cost, and an enabling social, economic, and regulatory environment. It is also influenced by the ability of entrepreneurs to bring the technology into the market.

Andrews et al identify the pace of technological diffusion as a key factor that determines productivity.[18] Technologies are developed and quickly adopted by leading firms across the globe, but are adopted much slower by firms lagging behind the technological frontier.[19] This lack of diffusion could be due to the 'winner takes most' dynamic in new technology sectors, but also due to increased barriers of entry caused by difficulties for laggard firms to undertake complementary firm-specific investments needed to benefit from new technologies.[20]

The adoption of new technology requires absorptive capacity and can involve significant costs including material, employee training and production shutdowns. With uncertainty about demand and ability to recoup costs, firms may be unwilling to incorporate new technologies even if they have the potential to raise productivity. In terms of potential benefits, an important factor in a firm's decision-making process is the cost of labour. This partly explains why developing countries with abundant cheap labour lag in the adoption of advanced technologies.

18 Andrews, Dan, Chiara Criscuolo, and Peter N. Gal (2016), The Best versus the Rest. OECD Productivity Working Papers 5. doi:10.1787/63629cc9-en.

19 Comin and Ferrer (2013) documented a decrease in the time it takes for technology to be adopted across countries in the last two centuries. For example, while it took 11 years after the invention of the computer for it to be adopted in Vietnam, it took over 120 years for the steam engine to make its way from the United Kingdom to Indonesia. However, the time for diffusion of technologies after the initial adoption within a country has increased.

20 It should be stressed that there are also non-technology related factors behind the productivity slowdown, which may be dominant. Adler et al. (2017) identified repairing balance sheets and disruptions of credit mechanisms in the wake of the recent global financial crisis as key, while also stressing the importance of secular factors.

B. The economic impact of the globalization of technology[21]

Adopting technology—be it new inventions or simply the new use of existing inventions—has both positive and negative effects on economies. The net effect of these opposing forces on growth, jobs and inequality can vary widely depending on the type of technology, the speed of its diffusion, and country-specific conditions, policies and institutions.

On one hand, the more pervasive use of technology has historically been linked with growth and more jobs. First, technology-led automation complements specific job tasks. This makes workers more productive and more valuable, boosting demand for such labour. Second, technological diffusion propels new industries and products, often meeting previously unfulfilled human needs and generating additional employment. Third, adopting technology positively impacts productivity, driving down costs and prices. This raises demand, thus increasing production and employment. Fourth, productivity gains lead to an overall increase in economic growth and income, thus creating higher demand for both new and existing products and services.

On the other hand, the use of technology allows for greater automation of production, replacing human labour. This is often achieved by substituting capital for labour, with new machines performing tasks that were previously carried out by humans. The tractor, the combine harvester, the forklift and desktop publishing software are prominent examples of labour-saving technologies.

21 This section is based in part on DESA/DPAD (2017), "The impact of the technological revolution on labour markets and income distribution", July. Available at: www.un.org/development/desa/dpad/publication/frontier-issues-artificial-intelligence-and-other-technologies-will-define-the-future-of-jobs-and-incomes/ .

C. Link between technology and structural transformation

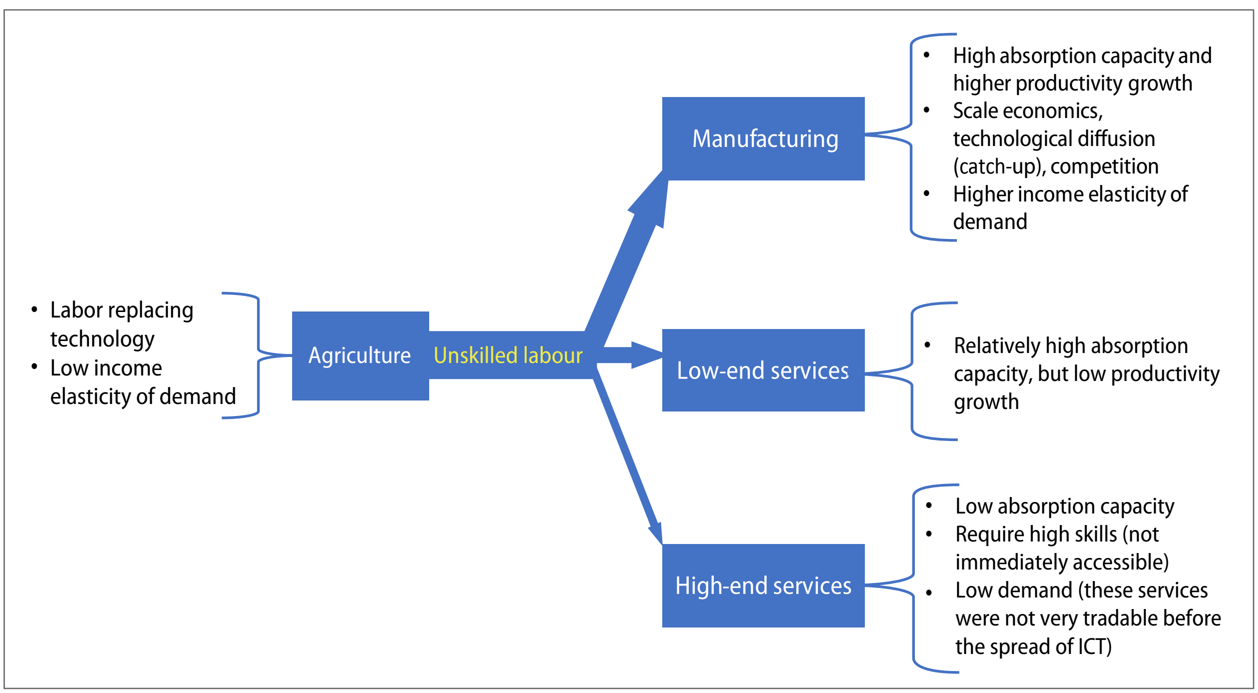
Nowhere has the diffusion of technology been more transformative than in the agricultural sector. Mechanization has raised yields by reducing the work involved in seed planting, fertilization and harvesting. Improved irrigation systems have reduced manual labour and made water use more efficient. Improved seeds through breeding and genetic modification have contributed to better resilience to diseases, floods and droughts.

These productivity gains have led to large declines in agriculture employment. Between 1820 and 1913, over the course of the first two industrial revolutions, the share of the United States labour force employed in the agricultural sector shrank from 70 per cent to 28 per cent and currently stands at less than 2 per cent. The share of agricultural employment in China fell from 81 per cent in 1970 to 28 per cent in 2015. However, in most least developed countries (particularly in Sub-Saharan Africa), the agricultural sector still employs a majority of the population. In 2016, agriculture accounted for 69 per cent of total employment in this group of countries, a slight increase compared to 1991.

The adoption of labour saving agricultural technologies released unskilled labour to the manufacturing sector, which employed technologies that allowed companies to make use of the new supply of workers (figure 11). With few exceptions, countries that have grown into high income countries today have undergone a similar structural economic transformation. In the last three decades, this structural change has been the pattern of several predominantly Asian countries, leading to high productivity and income gains.

Many other developing economies have failed to instigate this transformation despite low labour costs, however, in part due to policies that short-circuit the process described above. Import-substitution policies (curtailing trade and its benefits), insufficient basic infrastructure, opaque institutions, lack of legal protection, conflict and instability, and other factors

Figure 11
The manufacturing export-led growth model



Source: graph is based on description of the manufacturing export-led growth model in World Bank (2017), Jobs in Global Value Chains. Jobs Notes; No. 1. World Bank, Washington, DC.

that inhibit the types of investments in scale and technology that carry large development benefits.

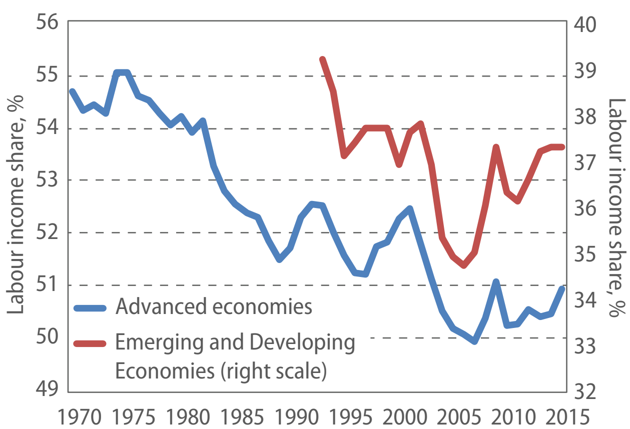
As a result, many of todays' least developed countries have experienced (and are experiencing) a large migration of unskilled labour (especially youth) from rural areas to urban centres where they often end up in unemployment or employed in the informal sector and/or in low-end services with low productivity. The consequences have been a rapid urbanization coupled with rising slums, high youth unemployment, pressure on basic services, and a deterioration of social cohesion.

D. The impact of technology globalization on inequality

Technology can impact wages and inequality by changing the factor composition of capital vs labour in production and/or by impacting the returns to different skill (low, middle, high) groups. The combination of the globalization of technology and offshoring of production has led to a polarization of jobs and wages in developed economies. In a sample of 16 European countries for the period 1993-2010, the average employment share of middle-paying occupations declined from 47 per cent to 38 per cent. Recent work by the World Bank[22] indicates that labour markets have also become more polarized in many developing countries since the mid-1990s. Some notable exceptions to this trend include China and Ethiopia.

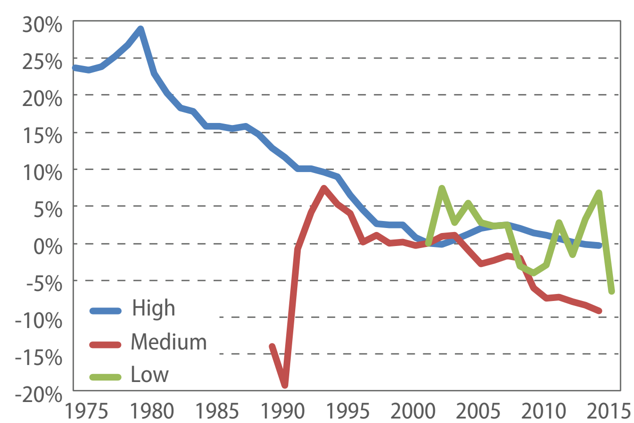
In some cases, this job polarization has been accompanied by rising wage inequality. Since 1970, the real wages of high-skilled workers have not only risen faster than those of medium-skilled workers whose jobs are declining, but also faster than those of low-skilled workers. This trend is particularly evident in developed countries. Among developing regions, the trends are mixed. In Latin America, the 90:10 ratio increased from the early 1980s until the late 1990s, but has declined since then. By contrast, many East Asian countries, including Indonesia, Republic of Korea, the Philippines and Viet Nam, have seen a relatively steady increase in wage inequality since the 1990s.

Figure 12a
Labour income share



Source: World Economic Outlook, April 2017, Chapter 3, Figure 3.1.

Figure 12b
Relative price of investment goods (percent change relative to 2002)



Source: WDI database, investment deflator divided by consumption deflator.

22 World Bank. 2016. World Development Report 2016: Digital Dividends. The World Bank. https://doi.org/10.1596/978-1-4648-0671-1.

Income inequality is also influenced by the relative distribution of income between labour and capital, which again is affected by the growing use of technology. Karabarbounis and Neiman have documented a global fall in labour income share (LIS) since 1970 and their findings support the view that technology plays a key role in determining LIS.[23] Through empirical analysis, the 2017 World Economic Outlook assigns about half of the overall decline experienced in advanced economies to a corresponding fall in the relative price of investment (RPI) goods to consumption goods (see figures 12a and 12b).

As labour income accounts for a larger share of income for households at the bottom of the distribution than for those at the top, and capital is typically more unevenly distributed across capital owners, a fall in the labour share in national income is associated with a worsening income distribution.

E. How the globalization of technology affects the LDCs[24]

Globalization of trade, finance and migration is often seen as the main driver of trends in labour markets and inequality in both developed and developing countries. The spread of knowledge and technology around the world complements this broader picture of globalization. Technological advances in logistics (in particular the introduction of the container), communications and finance played a major role in reducing costs and time of cross-border transactions, thereby facilitating globalization. A recent study estimates that maritime trade would decrease by one-third if container technology did not exist.[25]

In the current phase of globalization, a large part of trade is due to offshoring and outsourcing that enables the emergence of GVCs (where different steps of the production process are undertaken by different firms in different parts of the world). GVCs provide opportunities for firms also in developing countries to integrate into global markets and have created jobs in developing countries, and evidence shows that particularly women have benefitted by the job-creation in the labour-intensive chains.[26] However, many poorer developing countries lack the necessary skills and infrastructure to participate. The ability of a country's exporting firms to innovate and remain competitive ultimately depends on their ability to adopt technology as well as other factors, including the size of the exporting sector, the skill level of the workers, the availability of finance, and the size of the export and domestic markets.

Because of this, LDCs have the most to benefit from the greater use of technology, but are perhaps the most challenged by the uneven globalization of technology and knowledge. The biggest economic challenge confronting the world's 47 LDCs is the move of production and labour from low- to high-productivity activities, the process by which East Asian and developed countries industrialised through technological catch-up as outlined in figure 11 above. Some LDCs have largely been excluded from this industrialization process and have even experienced a stagnation or decline of their already limited manufacturing sectors, falling manufacturing labour productivity and a rise in underemployment as people migrate to cities as workers in low-end services and the informal economy.

Agriculture, where 60 per cent of LDC employees work, is the sector in which technologies could have the greatest impact in raising worker productivity. For example, drones have the potential to scout crops and to reduce the work involved in seed planting and fertilization. Automated irrigation systems can enhance precision and reduce manual labour.

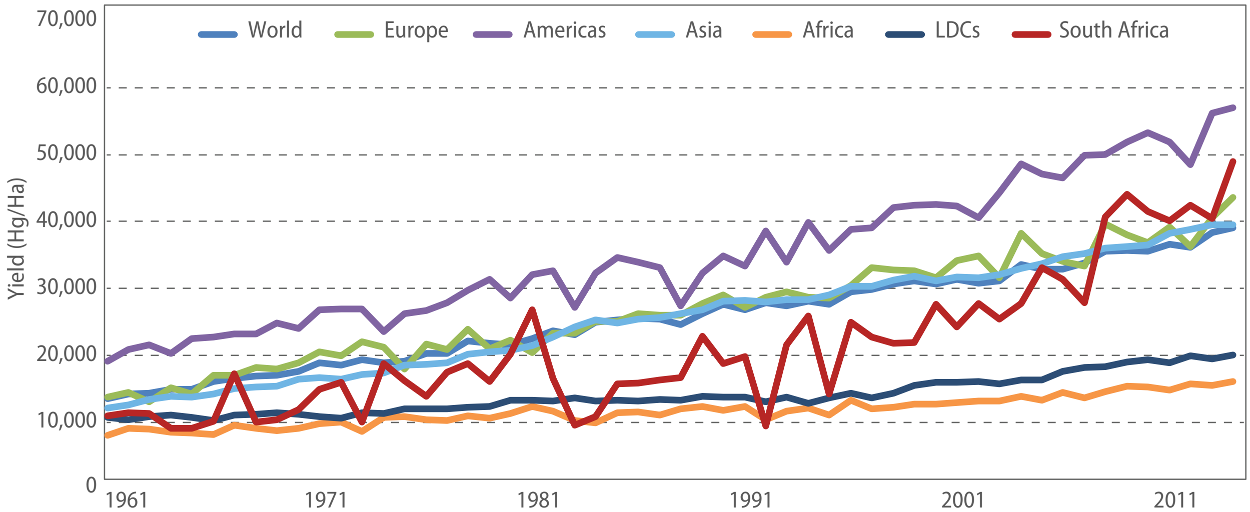
23 Karabarbounis, Loukas and Brent Neiman (2014)."The Global Decline of the Labor Share". Quarterly Journal of Economics, 129(1), 61-103, February 2014.

24 "LDCs and the Technological Revolution." Support Measures Portal for Least Developed Countries. www.un.org/ldcportal/ldcs-and-the-technological-revolution/.

25 Cosar, Kerem and Demir, Banu (2017), Shipping Inside the Box: Containerization and Trade CEPR Discussion Paper No. DP11750. Available at SSRN: https://ssrn.com/abstract=2896040

26 World Bank (2017), Jobs in Global Value Chains. Jobs Notes; No. 1. World Bank, Washington, DC.

Figure 13
Total cereal yield (hg/ha) 1961–2014



Source: FAOSTATS.

The genetic modification of seeds, although controversial, can increase disease-resilience, flood and drought resilience.

Instead of reaching this potential, LDCs are lagging behind in the adoption of technology. This can partly be illustrated by looking at differences in agricultural yields which are much lower for the Africa region and LDCs (figure 13). Africa's and LDC's yields have been stagnant throughout most of the period only rising very slowly since the late 1990s. This is the picture in many LDCs which despite of having increased agricultural output, have done so almost exclusively by increasing land under cultivation, not by increasing productivity. It should be noted that lack of productivity increases can be explained by several other factors (e.g. climate conditions) than technological differences. However, lack of technological adoption is likely to explain a large part, and it can be shown that lower income countries have lower fixed capital investment as a share of agricultural output.[27] South Africa, which shares similar climate conditions as several LDCs, is also included in the graph, and it can be seen that yields are higher and productivity increases relatively fast from the mid-1990s.

Yet the very labour-saving and productivity benefits of technology represent a threat to countries with abundant labour supply. Just at a time when rising Chinese labour costs presented an opportunity for LDCs to industrialise by attracting low-wage manufacturing, some of those jobs are likely to be mechanised with the advancement and adoption of new technology. As technology is globalized, low labour costs are likely to matter less for investment decisions, and competitiveness will depend mostly on the ability to use technological advancements – particularly labour-saving technologies.[28]

F. Technology's potential for leapfrog solutions and market development in LDCs

Whether new technologies will make developing countries more or less attractive manufacturing locations is still difficult to say. As pointed out by a recent World Bank report, the bar for establishing and maintaining competitiveness in global

27 See e.g. Butzer, Rita; Mundlak, Yair; Larson, Donald F. (2010), Measures of Fixed Capital in Agriculture. Policy Research working paper; no. WPS 5472. World Bank.

28 World Bank (2017), Jobs in Global Value Chains. Jobs Notes; No. 1. World Bank, Washington, DC.

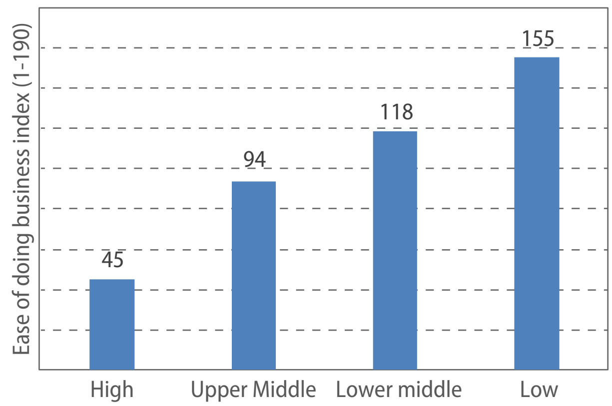
manufacturing is likely to be raised across all manufacturing subsectors.[29] Policy recommendations have not changed fundamentally, but implementation should be sped up to minimize the risk for some countries of being left behind further, and for other countries to lose what they have already gained.

As new technologies are likely to reduce labour-cost's share in total production cost, it should still be possible for LDCs to establish themselves as attractive investment and manufacturing destinations if they are able to combine their high (and rising) supply of low-cost labour with policies that will reduce other (than labour) costs of production and doing business. Broadly speaking, it is about improving the business environment and much of this still boils down to the lack of roads, bridges, ports, access to electricity, communications infrastructure, inefficient administrative procedures, weak institutions, underdeveloped capital markets, etc. – in short, a high perceived risk/cost of doing business in these countries regardless of how cheap labour might be.

Part of such cost/risk is bound to be captured in the Ease of Doing Business (EDB) index (figure 14).[30]

Several LDCs are investing in communications infrastructure that relies on wireless and cellular technologies, doing away with costly landline infrastructure. Another related issue is the lack of energy infrastructure. Lack of access to electricity, power volatility and high generation costs are major impediments to investments and growth in LDCs where less than 40 per cent of the population has access to electricity (figure 15). New renewable energy (RE) technology shows great promise in its ability to solve these problems, hence for some LDCs with an

Figure 14
Ease of Doing Business index, by income groups, 2016



Source: World Bank's Ease of Doing Business Index

abundance of RE sources to leapfrog - i.e. establish the necessary power infrastructure at a lower cost.

Recently, solar technology has made solar power the cheapest source of energy in the world. The cost of producing solar panels roughly drops by 28 per cent every time output of panels double, something economists assign to a technological experience curve effect.[31] The main problem with RE is the fact that generation is volatile (sun, water, wind changes) which means that in some cases RE sources generate more energy than demanded and vice versa. Balancing this mismatch is still a costly affair as energy storage technologies (batteries) are relatively expensive. But, this is also likely to change as producers increase output and move along the experience curve. E.g. the cost of batteries has dropped by 80 per cent over the last decade.

World energy consumption has more than quadrupled since 1975, however the share of gas, coal and oil in power generation has increased over the same period.[32] New RE technologies could be a game changer for the entire world, but maybe especially

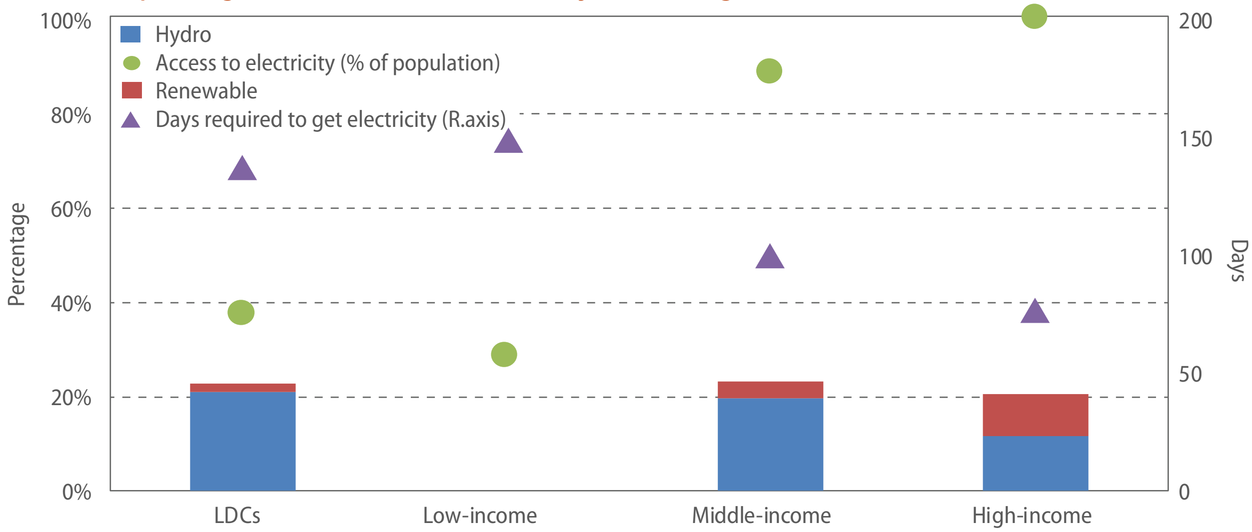
29 Hallward-Driemeier, Mary; Nayyar, Gaurav (2017), Trouble in the Making? The Future of Manufacturing-Led Development. Washington, DC: World Bank.

30 The Ease of Doing Business Index scores countries from 1 (best) to 190 (worst) based on 10 parameters of doing business, ease of; Starting business, getting construction permits, accessing electricity, registering a business, registering property, getting credit, protecting minority investors, paying taxes, cross-border trading, enforcing contracts and resolving insolvency.

31 The costs reductions over time is referred to as a learning/experience curve effect and captures; economies of scale, R&D, Learning by doing and learning by waiting elements.

32 According to the World Bank (WDI) the share of oil, coal and gas in total electricity production was 58.5 per cent in 1975 and 66.3 per cent in 2014.

Figure 15
Renewable power generation, access to electricity and waiting time



Source: World Bank World Development Indicators. Data shown is for 2014. Data on hydroelectric and other renewable sources for low income countries is not available.

for developing countries as they have a comparative advantage in RE capacity and have the largest power infrastructure gaps to fill. But, further cost reductions in RE technologies are likely to require policy support aimed at underpinning and increasing demand for RE technology and investments in RE R&D.

There are likely many other technological leapfrogging possibilities in other sectors, e.g. health and education (human capital). In tandem with the expansion and use of ICT infrastructure, Blockchain technology could potentially help reduce costly administrative procedures and increase accountability and transparency in government to business transactions (permits, licenses, tax payments, etc.).

Digital Finance (DF) solutions also help to reduce market failures (adverse selection and asymmetric information problems) and reduce financial transactions costs which can help develop financial markets and increase financial inclusion in a range of financial services. By pushing down administrative costs DF technologies are making lower-income market segments more attractive for financial service providers. It also offers potential borrowers with a means of formally and digitally track their cash flows (generate historical records) to help them better understand and optimize their businesses and access credit.

DF technologies enable better credit assessments and offer new ways of monitoring agents and reduce monitoring costs. This will enable a better resource allocation and cut collateral requirement and/or interest costs for borrowers which are especially high in developing countries. SMEs and households face a number of financial constraints; high participation cost, high collateral requirements (borrowing constraint) stemming from limited commitment problems and high intermediation costs stemming from asymmetric information.

G. Social impact of the globalization of technology

Technology (especially ICT technology) is changing the way and frequency by which people and institutions communicate. It is producing vast amounts of (Big) data and information on individuals and businesses and enables instant dissemination to a global audience at almost zero marginal cost. It is facilitating social global platforms and can promote greater social inclusion and social cohesion by promoting the integration and the inclusion of individuals.

ICTs, for example, improve information and accessibility of public services, legal rights, skills training, jobs and markets. The growing availability of mobile phone texting and internet, for instance, can better connect individuals with family, friends as well as social networks that enable people to organize. ICTs also foster transparency and accountability in government. The Internet, social media networks and mobile technologies enhance public participation and service delivery and support social mobilization. Online civil society platforms, such as Por Mi Barrio in Uruguay and I Change My City in India enable urban residents to report public service problems. Such initiatives can reinforce rather than replace existing accountability mechanisms, and rely on traditional mobilization when needed.[33]

There remains a large inequality in access to such technologies, however. The exclusion of segments of a society from the full benefits of technology widens disparities and social exclusion in many respects.[34]

In education, the availability of free or low cost online courses, including Massive Open Online Courses, has greatly expanded the opportunities for continuous learning. Since 2011, 58 million students have registered for at least one online course. By 2016, there were over 700 universities providing over 6,800 courses online.[35] Students and workers with the language skills and access to appropriate ICTs can learn new skills and invest in their own human capital. Incentives from educational institutions, private organizations and the public sector can help expand the availability of these programs. Public expenditures in labour market programs (training and job search, for example) already support workers during job transitions. In 2015, OECD member countries spent an average of 0.13 per cent spent on training for workers. Technology can expand the effectiveness of these programs and of traditional education. In developing countries, greater access to ICTs will bring these new opportunities for education to a larger number of people. However, it is important that education is linked to employment opportunities.

ICT technology is contributing to the generation of massive amounts of data from sensors, activities on social media, digital pictures and videos, purchase transactions and cell phone GPS signals, etc. IBM estimates that 90 per cent of all the data in the world has been created in the last two years.[36] All this (Big) data is increasingly being combined with machine learning and other advanced algorithms (often referred to as artificial intelligence) to improve companies' marketing and pricing strategies, but also by political campaigners to target voters, so-called political-microtargeting. In that sense ICT can help businesses sell and price products better and increase consumer satisfaction, and help politicians in securing votes with tailormade messages. But, it also makes it increasingly challenging for consumers to understand how much sensitive data is being collected on them and the process in which the data is being used to target them with products, messages and other information. Many people are surprised when presented with the magnitude and details of data available on them, and know only little about their rights and options available to protect their privacy, and the legal frameworks governing it.

On the other hand, ICT technology also provides governments with new opportunities and tools for exercising political and social control. Governments can use technologies to track and analyse online activities, to gauge public opinion, and to contain threats before they spread by e.g. predicting and taking actions to prevent the formation of likely protests.[37] Twitter activity was e.g. a good predic-

33 World Bank. 2016. World Development Report 2016: Digital Dividends. The World Bank. https://doi.org/10.1596/978-1-4648-0671-1.

34 United Nations (2016), Report on the World Social Situation.

35 https://www.class-central.com/report/mooc-stats-2016/

36 See e.g. 10 Key Marketing Trends for 2017, IBM Marketing Cloud.

37 Strömberg & Wu (2017), Why does China Allow Freer Social Media? Protests versus Surveillance and Propaganda.

tor of protests in Tahir Square during the Egypt's Arab Spring, suggesting that social media helped coordinate street mobilizations.[38]

The number of online media sources have increased rapidly along the development of ICT. Today many people get their news from a multiple of online media sources. While it gives consumers more options and can offer alternatives to media/news monopolies, it has also been linked to the spread of disinformation. At the same time, there is also an increasing tendency for people to seek out "echo-chambers" communities with people that have similar views, which may undermine the influence of objective expertise.[39] The speed and reach of ICT-enabled communications has helped with mobilizing online support and forming global coalitions on different global causes and issues which require urgent action.

There are also more atypical examples on how the spread of technology can impact social norms. In Brazil, it has been documented that the spread of technology, and with it the use of television, has had an effect on reducing fertility through the airing of soap operas portraying families with fewer children.[40] This fits into a larger discussion in the demographic literature on how the spread of ideas and norms affect fertility behaviour.

H. The globalization of technology and the environment

The progress of technology is associated with the rapid growth of economies and societies, and the pressure this has placed on ecological systems. All technologies consume resources, and may use land and pollute air, water and the atmosphere, albeit to varying degrees.

However, technology is central to solving environmental problems. The impact of the globalization of technology can best be thought of based on its potential. The globalization of technology, or its diffusion, will have a large influence on the future path of the environment and the mitigation costs associated with limiting climate change. The Intergovernmental Panel on Climate Change (IPCC) expects that the mitigation costs increase substantially under the absence or limited availability of technologies.

Technological progress and diffusion have led to large price reductions in the manufacture and installation of renewable energy capacity. Many technologies used in renewable energy systems achieved a level of maturity to enable deployment at significant scale, and many others are progressing rapidly in performance and cost. For example, globalization of markets in the solar photovoltaics (PV) and wind turbines contributed to the rapid reduction in price of this technology. The large increase in the volume produced enabled firms to quickly move than the experience curve and reduce costs. As a result, energy generation from modern renewables (particularly solar PV and wind power) has increased at more than twice the rate of energy demand over the past 10 years. The share of renewable energy in power generation rose from 19.6 per cent in 2010 to 22.3 per cent in 2014.[41]

4 How the multilateral system can promote greater access to the benefits of technology

Technological innovation and its diffusion is a main engine of productivity growth, but for many countries, basic or advanced technologies remain practically inaccessible. Over a billion people lack

38 Acemoglu et. al (2014), The power of the street, Evidence from Egypt's Arab Spring, NBER Working Paper Series, November 2014.

39 OECD (2017), Fixing Globalisation: Time to Make it Work for All, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264275096-en

40 La Ferrara, E., A. Chong, and S. Duryea (2008), Soap Operas and Fertility: Evidence from Brazil, CEPR, Discussion Paper No. 6785.

41 United Nations (2017), The Sustainable Development Goals Report 2017.

electricity. Three billion lack access to clean and safe cooking technology. 29 per cent of the global population lack a safe source of water, and 61 per cent lack safe sanitation. The technologies to solve these problems exist, but many factors have limited their diffusion.

How the greater use of existing and new technologies will foster progress towards the 2030 agenda for sustainable development, ultimately depends on the institutions and policies that are in place at the national and global level. In devising policies and shaping institutions, Governments need to consider that they operate with significant uncertainty, and this would support a trial-and-error approach that can be adapted according to new experiences and developments.

Overall, Governments play an active role in promoting the adoption and diffusion of new breakthrough technologies. At the same time, they must ensure that the gains are broadly shared and that displaced workers can find new, high-quality jobs. The kind of policies and institutions that will best achieve these ends will depend on country-specific conditions.

As technological changes are of global nature, it will be impossible for a single country alone to effectively address these challenges. The rapid pace of technological change requires a pro-active approach to anticipate the developments and to formulate potential solutions collectively. Governments and multilateral organizations, need to reflect on new forms of collaboration and multilateralism in view of the globalization of technology and knowledge.

The policy options should try to address how both intended and unintended consequences of globalization of technology could be more efficiently identified and addressed at the national, regional and global levels. The discussion will also try to address how equitable sharing of the burdens and benefits of globalization of technology can be achieved, and propose national and global policy approaches to ensure that no one is left behind from the benefits of technological change.

A. National level policies

New development pathways in the time of technological change

New technology is likely to raise the bar on what makes a country an attractive location for manufacturing. For developing countries, policy must mitigate the risks that less-industrialized countries (predominantly low-income) will be further left behind and make sure that countries that have managed to gain a foothold in the industrialization process and take positions in GVCs sustain and build upon these.

Policy recommendations aimed at increasing manufacturing are not fundamentally going to change with new technology, but the sense of urgency in their implementation is likely to. Broadly speaking low and middle-income countries must implement policies that strengthen their competitiveness, capabilities and connectivity to ensure they benefit and continue to benefit from technological changes.

Concerning competitiveness – for less competitive countries the main priority should be improving the business environment and for countries already connected to GVCs policy aimed at shifts in resource allocations and new issues in competition policy such as setting competition policy framework for network platforms, adjust regulation for new business forms, facilitate contracting to enable greater use of sharing economy on production side, develop programs to strengthen more advanced skills and creativity and support the development of data and data ecosystems and support workers during transitions.

Concerning capabilities – skills investments will be key here for countries low and high on this parameter as jobs across all manufacturing subsectors are likely to become increasingly non-routine and cognitive. This will require investments in the development of ICT skills such as programming and coding or complementary skills in engineering. The importance of soft skills that foster creativity, problem solving and initiative are likely to become more important. On the firm-side R&D subsidies in the area of new technologies should – dependent on stage of firms

– be accompanied by 1) fields services to support managerial and organizational practices 2) technology-oriented services and technology centers for the adoption of more complex technologies and 3) R&D centers to support the generation of new technologies. For countries with less capabilities Quality Infrastructure (QI) should be emphasized to facilitate the certification of internationally recognised standards. For countries with higher capabilities regulatory issues related to IP rights, data-security and privacy are likely to be more pressing.

Concerning connectedness – for less connected countries emphasis should be on further reducing restrictions on the import of intermediate inputs and secure market access in their destination markets, as tariffs and non-tariff measures remain high in some sectors. Policies that address logistics issues including the easing of border clearances are also important. Service sector reforms become more urgent for all countries as services are increasingly embedded in the production and sales of goods. Trade service restrictions will become ever costlier. Restrictions on cross-border dataflows will restrict the use of new technology and should be addressed, again highlighting the importance of IP and privacy protection.

A key takeaway for policymakers is that the bar for becoming an attractive manufacturing location is likely to rise more in some manufacturing subsectors than others. Countries can use this information to assess which development pathways are more feasible for them depending on their most pressing needs, assessed based on four dimensions: the level of automation, export (market) concentration, (professional) services intensity and international trade concentration. For many low-income countries, the main problem will continue to be job creation given their high abundance of unskilled labour and demographic outlooks. Some low-end labour-intensive (less automated) sectors with less export (market) concentration and tradedness will continue to offer these less-industrialized countries entry points into manufacturing and act as drivers of low-skilled employment. Likewise, countries that have started the industrialization process based on low labour costs in labour-intensive sectors can remain cost-effective given the right policies.

Policies to promote adoption of basic technology

As discussed above, the diffusion and adoption of different basic technologies remain incomplete. In some cases, the problem is not simply access and coverage, but other socio-economic factors that hinder the use of basic technology. While it is important to promote better access and coverage, it will not always solve low adoption of various basic technologies by itself.

Social network analysis can also guide policy efforts to promote adoption of various technologies. Networks provide the medium through which people learn of an innovation and adoption by a trusted person then initiates a chain reaction of adoptions through the network. Social network analysis has also shown that targeting people central in the network could be more efficient for technology adoption.

Promoting the use of basic sanitation technologies, such as latrines, is an example of where the globalization of knowledge and technology can have direct impact on the wellbeing of individuals and communities. Studies on latrine use in India find that people in households with working toilets continue to defecate in the open, and that toilets provided by the state are unlikely to be used.

Large public awareness campaigns can promote the use of basic sanitation technologies, such as latrines. Understanding of and access to reliable context information is essential to inform choices. This can help overcome the concern of local communities, change public attitude and habits, and reduce the risk of failure in technology adoption or adaptation.

A study on latrine ownership in India finds that a person is significantly more likely to own a latrine if their social contacts also own latrines. Since people that are peripheral in the social network are less likely to own a latrine, and likely to have friends without latrines, intervention efforts aimed at the more peripheral community members will potentially have larger multiplier effects and be more efficient.

Policies to promote innovation at the national level

Policy measures to consider include the support to national (public and private) institutions of research and innovation, provision of infrastructure (e.g., broadband), support to business incubators that enable start-up firms to bring new technologies more quickly to markets or the promotion of networks of firms and non-state actors.

Strengthening national innovation systems will require building a domestic capacity to choose, absorb and promote the technologies that are most conducive to enhancing dynamic sustainable development.

Governments should also develop national strategies for science, technology and innovation comprising policy, regulatory and institutional frameworks that strengthen the enabling environment and enhance interactive learning. Countries must strengthen national systems of innovation, especially in developing countries.

Research and Development has an important role to play in achieving sustained long term growth. Governments should introduce policies to ensure that government spending on R&D remains stable and long-term oriented, and promote the use a variety of tools to incentivize and "crowd in" greater private investment in R&D.

Another priority is in creating an enabling environment for innovation and support entrepreneurship to ensure that innovations can be deployed for sustainable development. Policies should be designed in an integrated manner as part of the innovation system, to encourage interaction and knowledge-sharing among domestic and international firms, research institutes, universities, policymakers and other actors.

Science, technology and innovation policies should be coherent with other development policies — trade, foreign direct investment (FDI), and education, for example. For developing countries, initiatives to enhance absorption capacity and facilitate the diffusion of innovation deserve special attention

Policies to remain competitive and protect workers

Education and training systems must prepare workers to be flexible and to develop new skills in response to rapid changes brought by new technologies. To remain competitive in jobs that are complemented by AI, workers must acquire the necessary skills during their schooling or as part of job training.

Rapid technological change has contributed to increased wage inequality among workers, as well as between workers and firm owners. Progressive tax policies could ensure that benefits from new technologies, such as AI, are more widely shared.

Progress towards universal social protection systems needs to accelerate in developing countries to extend coverage to workers in non-standard and informal employment.

B. Global policies

International cooperation includes at least three different dimensions: sharing of and learning from national experiences, providing support for disadvantaged countries, and addressing the cross-border aspects of new and existing technologies.

Exchange of lessons learned

As countries continue to experiment with policies and regulations related to new technologies, there is scope at the international level to exchange lessons learned at the national level. The sharing can address not only the question of how policies and country-specific conditions influence the development and diffusion of new technologies, but they can also address the broader question of how these technologies contribute to the larger goal of achieving sustainable development.

Countries should further promote the "Technology Facilitation Mechanism" (TFM) in order to support the implementation of the Sustainable Development Goals (SDGs). The TFM will facilitate multi-stakeholder collaboration and partnerships through the sharing of information, experiences, best practices and policy advice among Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders.

For example, international deliberations on automation and AI and their implications for sustainable development have started in the Multi-Stakeholder Forum on STI for the SDGs ("STI Forum"), mandated by the 2030 Agenda. These deliberations benefit from the dialogue between representatives of governments, science, business and civil society.

Facilitate technology transfer and capacity building to disadvantage countries

A number of regional and international initiatives promote STI in LDCs.[42] For example, UNESCO helps LDCs to monitor and evaluate the implementation of their STI policies. WIPO advises countries on opportunities available under international IP treaties and assists them on how to leverage IP into areas such as health, trade, education, research, technology transfer and competition policies. The World Bank together with GÉANT and the EU are working to expand national research and education networks across developing countries. The African Regional Intellectual Property Office provides training on intellectual property legislation and technology transfer. Research4life is a public-private partnership between four UN agencies and global publishers of online scientific, medical and technical publications.

Many developing countries will also require support to build necessary infrastructure such as broadband, to ensure that they can participate in economic activities depending on new technologies. Existing mechanisms of international cooperation need also to take into account that a new technological revolution might lead to increased inequality between developed countries and more advanced developing countries on one side and disadvantaged groups of developing countries such as the LDCs on the other.

Official development assistance (ODA) providers should aim to step up their contributions for capacity-building and research and development to African countries, least developed countries (LDCs) and landlocked developing countries (LLDCs) in the context of fulfilling their overall commitments.

Countries should further promote the Technology Bank that aims to help improve scientific research and the innovation base in LDCs, promote networking among researchers and research institutions, and help LDCs access and utilize critical technologies. It will assist LDCs in building their national and regional capacities in the areas of intellectual property rights and technology related policies, as well as facilitate the transfer of technologies on voluntary and mutually agreed terms and conditions, and in the process, accelerate the LDCs integration into the knowledge-based economy. It will be critical to establish the financial base as soon as possible to ensure that all LDCs can benefit from the new institution.

Reform of IPR regime

Regulations regarding intellectual property rights (IPRs) also affect innovation. Patents, copyrights and trademarks are meant to promote innovation by allowing firms to capture a larger share of the returns to their research investments for a specified period in exchange for making their inventions public. However, IPRs may also stifle innovation by locking in the advantages of incumbents and preventing other firms and countries from building on newly-invented technologies.

Managing global intellectual property rights is also crucial. Granting intellectual property rights constitutes, and should always remain, a public policy action, one whose intention is to consistently

42 Based on C Chibuye, M. and Zampetti, A. (2017). *'Enhancing STI in Africa through the Technology Bank'*, paper presented at the Expert Group Meeting on Governing science, technology and innovation to achieve the targets of the Sustainable Development Goals and the aspirations of the African Union's Agenda 2063, Addis Ababa, 2-3 August 2017.

stimulate—not restrict—private initiative in technological development.

As argued in a 2011 report by the United Nations, spurring technological development will require international public sector strategies which guarantee a commercial incentive substantial enough to enable private parties to use subsidies and public purchases of technology at reasonable cost in their research undertakings, while constraining monopolistic practices which restrict diffusion and further development. The new international regime should allow special and differential access to new technology based on level of development.[43]

The role of the United Nations

In addition to supporting the above-mentioned initiatives, the United Nations can provide innovative solutions to emerging concerns over the globalization of technology.[44]

The UN is an impartial and objective interlocutor and advocate among governments, private sector and civil society organizations. It can work to forge consensus around any proposed conventions and global agreements regarding technology, and help design and establish mechanisms for generation and diffusion of technologies that are imperative for sustainable development.

The UN is a natural forum for a discussion on any required modernization of the global institutional framework in order to better utilize the positive potential of technology as well as to deal the with potential problems that technologies can create. This discussion should build on the Addis Ababa Action Agenda (AAAA) and the Technology Facilitation Mechanism created at the United Nations.

This work can be supported by research, analysis and advice to Member States on the impact of emerging technologies on sustainable development outcomes, including impact on employment, wages and income distribution. Rigorous and robust research and analysis can inform and complement the work of the STI forum, the CSTD, ECOSOC and the General Assembly.

43 United Nations. 2011. World Economic and Social Survey 2011: The Great Green Technological Transformation. World Economic and Social Survey 2011. New York, NY: United Nations.

44 http://unitednetworks.ae/wp-content/uploads/2017/09/United-Networks-Tom-Fletcher.pdf