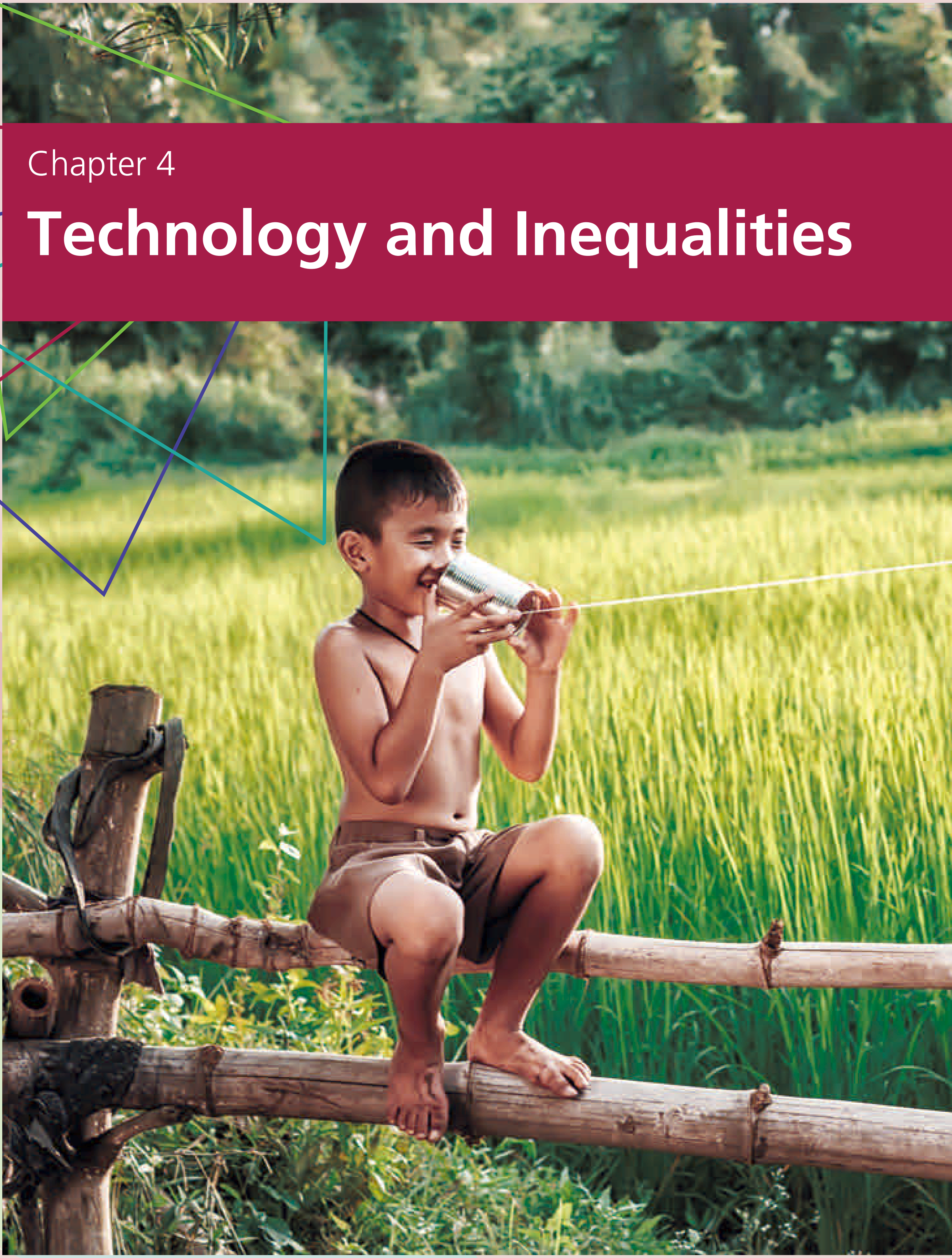
Chapter 4

Technology and Inequalities



4.1 HOW CAN TECHNOLOGY IMPACT INEQUALITY?

The relationship between technology and inequality is multifaceted. Technology has enhanced productivity, accelerated economic growth, enabled knowledge and information sharing and increased access to basic services. However, it has also been the cause of inequalities. This chapter examines the role of technology across the three facets of inequality discussed in the previous chapters: inequality of outcome; inequality of opportunities; and inequality of impact, which is concerned with the impact of environmental hazards on the most vulnerable.[1]

The chapter starts by underlining that digital connectivity is a core enabler of the emerging Fourth Industrial Revolution – a wave of highly disruptive innovations that will bring new big ideas and trigger additional layers of technological innovations that compel a rethink of all traditional responses, as societies, communities and even what it means to be human, is challenged. These future impacts cannot be underestimated. While digital innovation and the spur of the Third Industrial Revolution helped accelerate economic growth through the competitive participation of the Asia-Pacific region in the global supply chain, a number of low-income countries lagged behind and did not benefit equally from the digital revolution. Therefore, as frontier technologies go mainstream, a key policy concern given the speed, scale and depth of the changes ahead, is that the "digital divide" will amplify the "technology divide" and widen inequalities, across all three of its dimensions, and between subregions, countries and people. [2]

Technology, together with the opportunities provided by trade and investment for capital accumulation and productive transformation, has helped achieve an unprecedented level of economic growth in Asia and the Pacific, enabling several countries to catch up with developed nations. However, least developed countries (LDCs) and countries with special needs have not been able to build technological capabilities and are lagging behind.

The potential of technologies to reduce inequality in opportunities is vast but is not automatic. It largely depends on the capabilities of the poor to access and use technologies and solutions that respond to their needs. Technologies also play a critical role for reducing the impact of environmental degradation and disasters, which disproportionately affect the poor.

Policymakers seeking to ensure that technology contributes to, rather than undermines, equality face challenging questions:

- What role has technology played in creating and addressing inequality, in terms of income, opportunity and environmental impact in Asia and the Pacific?

- How will future technologies potentially reshape trends in inequalities in the region?

The rest of the chapter aims to answer these questions and provides policymakers with recommendations to ensure that technology as a means for implementing the Sustainable Development Goals (SDGs) reduces rather than accentuates inequality. A key message is that among the combination of enabling factors that are needed, public policy is key. Technologies and solutions need to respond to the needs of the poor, who need to be empowered to access and use such technologies.

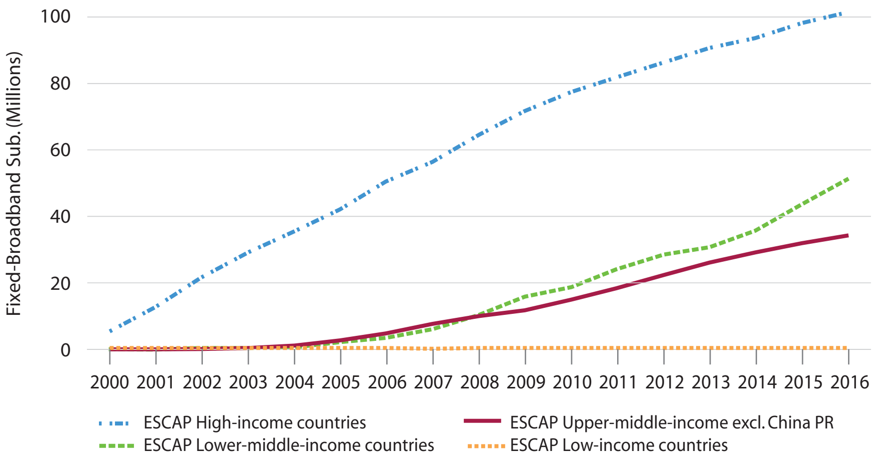
4.2 DIGITAL DIVIDE AND INEQUALITY

As the Third Industrial Revolution has evolved, information and communications technologies (ICT) emerged as a meta infrastructure – an infrastructure that reconfigures all other infrastructures into smart systems that accelerate socioeconomic development. More importantly, today as the Third Industrial Revolution morphs into the Fourth Industrial Revolution with the Internet of Things (IoT) at its core, artificial intelligence (AI) – that is machines performing cognitive, human-like functions – has emerged as the next technological frontier of sustainable development. As AI goes mainstream, its disruptive impacts are likely to be seen at an unprecedented speed and scale, which underlines the need for governments and stakeholders to discuss and shape their collective future.

Frontier technologies are based on huge quantities of real-time data, which are themselves critically dependent on high-speed (broadband) Internet. The existing lack of broadband connectivity across many Asia-Pacific countries means that the uptake, adoption and development of AI and other technologies will continue to be uneven.

Analysis of fixed (wired) broadband subscriptions across the region points to a widening digital divide, with an increase in coverage and quality in high-income countries (Figure 4.1). In 2016, in 18 low-income countries in the region, less than 2 per cent of the population had access to fixed-broadband– a level that has remained unchanged for nearly two decades.[3] This stands in sharp contrast with fixed-broadband subscriptions in East and North-East Asia, where it ranged between 22 and 41 per cent (Figure 4.2). Clearly, the digital revolution bypassed many countries in the region, many of which may also be bypassed by the Fourth Industrial Revolution.

Figure 4.1 Total fixed-broadband subscriptions by income group in 2000-2016, excluding China



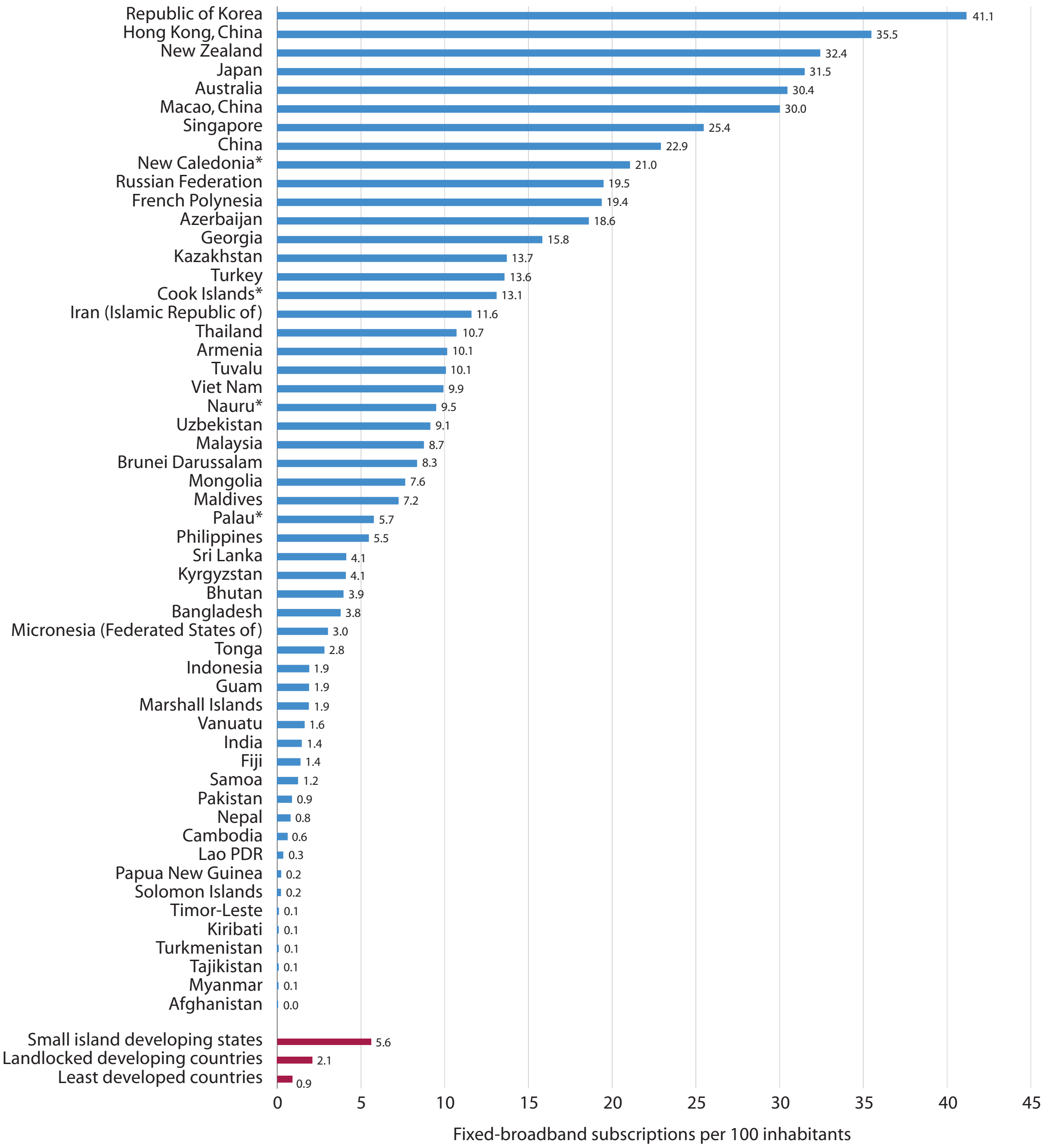
Source: ESCAP, based on data from ITU World Telecommunication/ICT Indicators Database (accessed July 2017).

A digital divide also exists within countries – between urban and rural areas and between men and women – driven by the availability, affordability and reliability of broadband services.[4]

The conditions, prerequisites and drivers of AI development and uptake show a positive correlation between the quantity of AI on the one hand, and market size, capacity for technology absorption and investment in ICT services on the other hand.[5] Thus the return on investment in AI is likely to be significantly greater among countries with a high capacity for technology absorption – a characteristic that tends to reflect inequalities accumulated in the past.

If current trends continue, AI and other frontier technologies may further increase income, opportunity and impact inequalities and widen development gaps among countries and people by providing transformative opportunities to those with the requisite

Figure 4.2 Fixed-broadband subscriptions in the Asia-Pacific region (percentage), 2016



Source: ESCAP, based on data from ITU World Telecommunication/ICT Indicators Database (accessed July 2017).
Note: * Countries with latest data available.

infrastructure, access, investments and knowledge, while those without are left further behind. The nature of each of these dimensions is analysed in the following three sections.

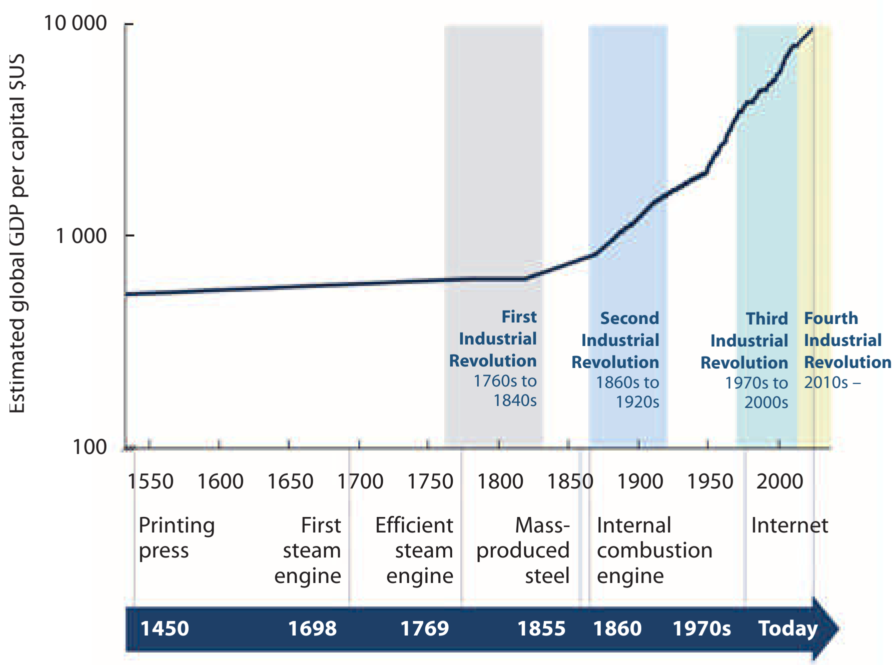
4.3 TECHNOLOGY AND INEQUALITY OF OUTCOME

The role technology plays in income and wealth inequality is complex and contested. Technology is a key driver of aggregate economic growth, through productivity improvements, but its contribution to economic growth varies greatly across countries. Technology can also be a driver of income and wealth inequality because of its skills-bias nature and because innovators can capture high rents. This section explores these dimensions, as supplemental to the drivers of inequality explored in previous chapters.

4.3.1 Technology as a driver of economic growth

Technology is considered fundamental to sustaining economic growth. The harnessing of water power, followed by the invention of an efficient steam engine in 1769, played vital roles in the First Industrial Revolution, which drove economic development in Europe. The internal combustion engine arguably sparked the Second Industrial Revolution, while the third has been driven by computers and the Internet (Figure 4.3).

Figure 4.3 GDP per capita growth and technology



Source: Adapted from "Disruptive technologies: Advances that will transform life, business, and the global economy," McKinsey Global Institute, May 2013, p. 24." The figure was derived from Angus Maddison, "Statistics on world population, GDP and per capita GDP, 1–2008 AD," the Maddison Project database. Data for 2008-2016 is GDP per capita (constant 2010 US$), from World Bank national accounts data (Available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD)

Note: the graph is on a log scale—the actual slope of the line after World War II is much steeper than visually depicted.

Technologies and, more broadly, innovation are central to long-term growth because of their impact on productivity. Technological capabilities, that is a country's capacity to acquire, absorb, disseminate and apply modern technologies, are thus fundamental to maintain broad economic growth.[6]

Quantifying the contribution of technology to productivity or economic growth is challenging, contested and approximative at best. It is challenging because technology is interwoven with other drivers of productivity and singling out its unique role is seldom straightforward. It is contested because multiple methodologies are used to evaluate its impact.[7] Total factor productivity (TFP), an aggregate measure of productivity first introduced by Solow (1957), has been the traditional measure of economy-wide technological change.[8] TFP is the portion of output not explained by the amount of inputs used in production, and represents how efficiently and intensely the inputs are utilized in production[9]. Changes in TFP can be explained both by technology changes and by non-technological innovation. It is approximative at best because of the difficulties in measuring inputs and outputs.[10]

The economic growth trajectories of the more advanced economies (including China, Japan and the Republic of Korea) have been sustained by technological capabilities.[11]

Accelerating economic growth in the LDCs and countries with special needs is key to reducing income inequalities in the region, but most of these nations are hampered by low technological capabilities. The extent of technological inequalities among countries broadly depends on three factors: investment in technological development, overall national capacity to innovate and the availability of ICT infrastructure. Regarding investment in technological development, 16 countries in the region (half of those surveyed) spent less than 0.25 per cent of GDP on R&D in 2015 (Table 4.1).

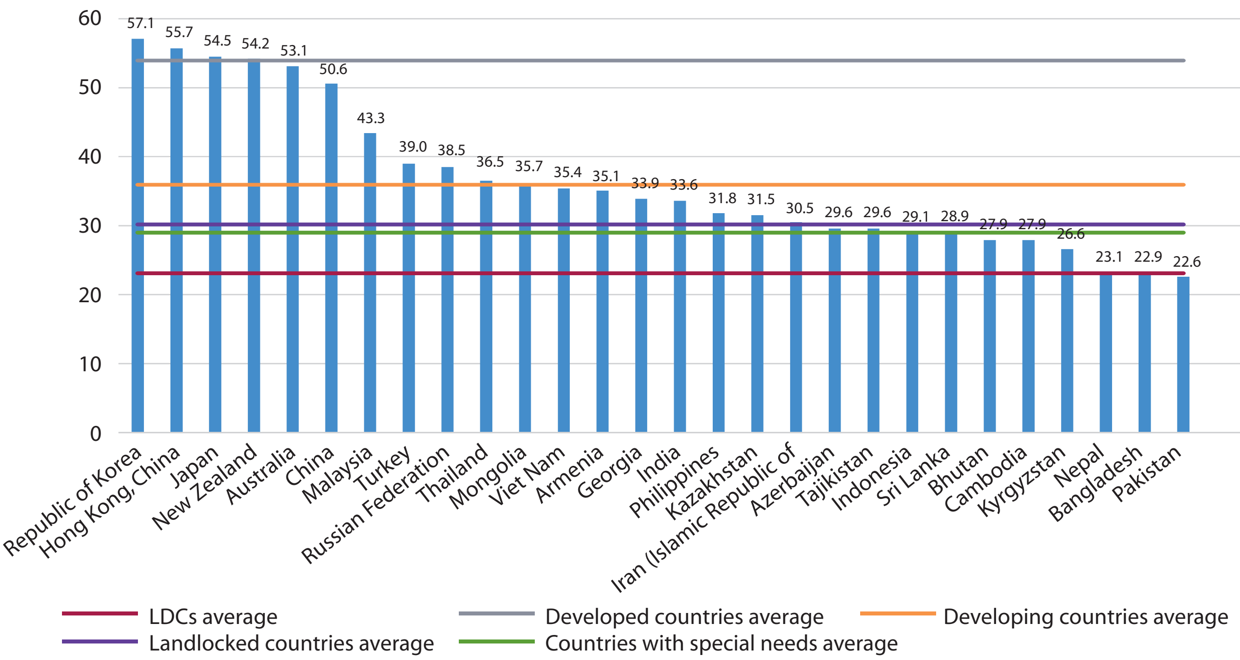
Regarding the overall capacity to innovate, including through non-technological innovation activities such as the reorganization of production processes or organizational improvements, among the LDCs in the Asia-Pacific region, Bhutan and Cambodia perform best in the Global Innovation Index (GII), but their scores are still well below the average for developing countries (Figure 4.4). Reasons for innovation weakness among LDCs and other countries with special needs include the low absorptive capacity of firms, weaknesses in knowledge generation (basic research capacity) and diffusion (limited vocational and STEM education and weak linkages between academia and industry). Weak framework conditions (where governance and market weaknesses inhibit FDI and curtail business activities), along with poor infrastructure (energy, transport and telecommunications) also constrain the development of technological capabilities.[12]

Table 4.1 Gross domestic expenditure on R&D in the Asia-Pacific region, 2015 or most recent year available, percentage of GDP

Republic of Korea	4.23	Thailand	0.63	Mongolia	0.16
Japan	3.28	Viet Nam	0.37 (2013)	Philippines	0.14 (2013)
Australia	2.20 (2013)	Iran (Islamic Republic of)	0.33 (2012)	Macao, China	0.13
Singapore	2.20 (2014)	Georgia	0.32	Cambodia	0.12
China	2.07	Nepal	0.30 (2010)	Kyrgyzstan	0.12
Malaysia	1.30	Armenia	0.25	Tajikistan	0.11
New Zealand	1.15 (2013)	Pakistan	0.25	Sri Lanka	0.10 (2013)
Russian Federation	1.13	Azerbaijan	0.22	Indonesia	0.08 (2013)
Turkey	1.01 (2014)	Uzbekistan	0.21	Lao PDR	0.04
Hong Kong, China	0.76	Kazakhstan	0.17	Brunei Darussalam	0.04 (2004)
India	0.63	Myanmar	0.16 (2002)		

Source: UNESCO, Institute for Statistics Data Center (accessed January 2018).

Figure 4.4 Global Innovation Index, Asia-Pacific countries, 2016



Source: Global Innovation Index. Available from: https://www.globalinnovationindex.org/analysis-indicator (accessed January 2018).
Note: Overall GII score, computed as the simple average of the Input and Output Sub-Index scores

The absence of basic technological capabilities (especially in terms of digital infrastructure and skills) will limit the ability of these countries to access, use and develop frontier technologies. Regulatory frameworks for AI and frontier technology also need to be in place before the digital divide becomes unbridgeable. This is important because automation may prove to be a double burden by reducing employment in manufacturing, but opportunities to develop technological capabilities, given also by limiting the role of the manufacturing sector as a vehicle for technological learning.[13]

4.3.2 Technology and its effect on jobs and wages

The adoption of technologies can sustain competitiveness. However, technology also affects the composition and nature of jobs available as well as relative wages. Jobs are being created and destroyed all the time and the net effect of technology on aggregate employment is ambiguous. Labour-augmenting technology can complement workers and increase their productivity.[14] Labour-saving technology (e.g. automation) can, on the other hand, substitute workers for machines in certain tasks. It can give rise to different jobs too. Empirically, the fears of massive unemployment have proven unfounded especially in the long term. Although unemployment may increase in the short-to-medium term because of the frictions in labour markets, technological changes have empirically shown small negative effects on long-term employment levels, and even positive effects in some cases.[15]

Regarding the effects of technology on the composition and nature of work, automation and robotic technologies tend to favour non-routine cognitive tasks while they are reducing demand for manual work. Robotics and AI tend to augment the tasks of high-skilled professionals such as engineering, customer-problem solving, management, medical diagnosis, software development, etc. New technologies also have the capability to take over routine tasks, for example manufacturing assembly and back-office work, which fall under the middle-skilled category.[16] As a result, automation can create employment polarization by "hollowing out" jobs in the middle of the employment distribution. Evidence is extensively documented in developed countries, such as the United States and the European countries.[17] In Asia-Pacific economies, the share of "middle-skilled" jobs in overall employment has been shrinking. China is an exception due to the growing mechanization in agriculture, which has led to an increase of routine jobs (Figure 4.5). Most of the economies that experienced a fall of middle-skilled jobs saw the share of high-skilled jobs increasing. However, the rise in high-skilled jobs was only able to offset the fall in middle-skilled jobs in three countries: Bhutan, Kazakhstan and Pakistan. This unbalanced shift in the composition of job markets can translate into rising income inequality as high-skilled workers will see higher wages while low-skilled workers will have to compete with displaced middle-skilled workers.

Figure 4.5 Changes in employment share by skill type, selected Asia-Pacific economies, annual average, 1995-2012

Source: ESCAP's compilation, using data from World Bank (2016).

Looking forward, the region can expect further job displacement. As labour costs in developing economies increase, tasks that can be automated will return to developed countries.[18] This trend could reduce the opportunity not only to create more jobs but also for industrialization and technological upgrading strategy based on labour-intensive manufacturing. Countries such as India, which aims to increase manufacturing value added to 25 per cent by 2020, from 16 per cent in 2015, could be affected.[19]

Technically, the share of jobs at risk of automation is high (Box 4.1). However, for now, robot deployment remains mostly confined to the manufacturing sector as automation in Asia and the Pacific is moderated by lower wages and slower technological adoption.[20] AI is considered to be the most important general-purpose technology in the new era and is expected to have the deepest impact, permeating all industries and playing an increasing role in daily life.[21] Research on AI is advancing quickly, but its application for most developing countries remains largely at a nascent stage.[22] Nevertheless, countries need to consider policies (regulatory and others) that would help them prepare for this technological change.

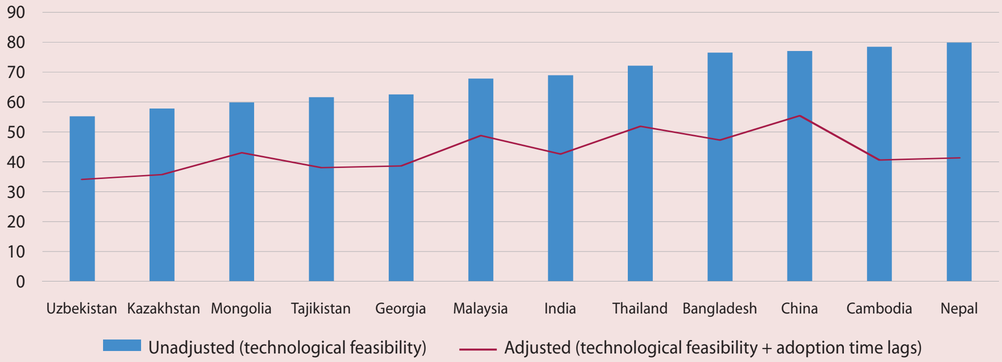
Empirical data on the impact of technology on income inequality across Asia and the Pacific is scarce. A recent study shows that the skills premium has been declining or stagnant in recent years in some countries, including Indonesia, Pakistan and the Russian Federation, and that there is a positive relationship between the skills premium and income inequality as measured by the Gini coefficient (Figure 4.6).[25]

Box 4.1 Automation and risk of job displacement

About half of all the activities people are paid to do globally, amounting to 1.2 billion workers, could potentially be automated by adapting currently demonstrated technologies.[23] The World Bank estimates that up to two-thirds of all jobs are susceptible to automation in the developing world. In the Asia-Pacific region the risk of jobs being automated is also high: 785 million workers or 51.5 per cent of total employment in the region.[24]

The share of automatable employment varies among countries and sectors, depending on the nature of the workforce and their tasks. Vulnerability to automation, based on technological feasibility, is estimated to range from 55 per cent in Uzbekistan to nearly 80 per cent in Nepal.

Estimated share of automatable employment



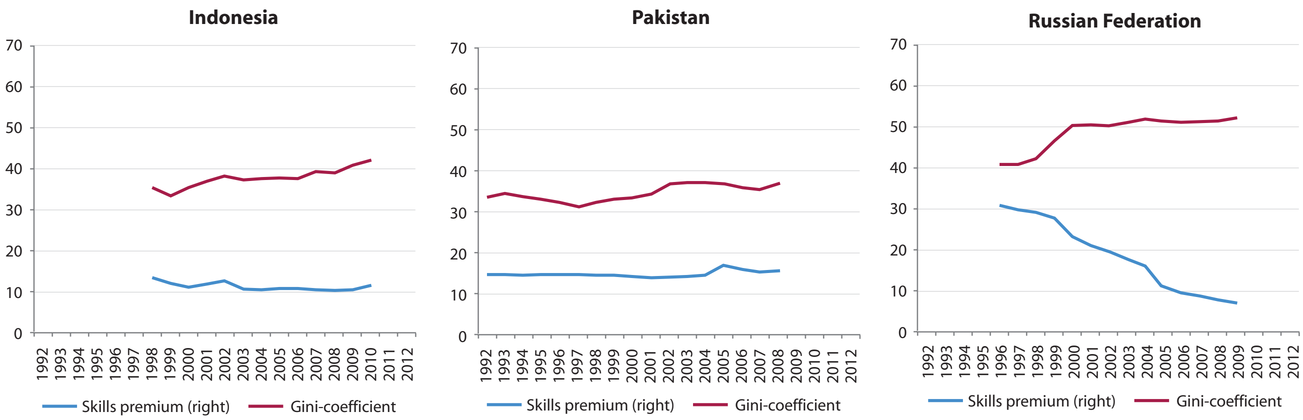
Source: ESCAP's compilation using data from World Bank (2016).

Similarly, findings from a firm-level survey for ILO by Chang et al. (2016) suggest that automation might have a significant impact on the job security of salaried workers in five major sectors of ASEAN economies: automotive and auto parts; electrical and electronics; textiles, clothing and footwear; business process outsourcing; and retail (from 60 per cent to 89 per cent, depending on country and sector). Additionally, based on data from MGI, 68 per cent of accommodation and food services jobs of major Asia-Pacific economies are technically automatable.

However, the automation effects are moderated by lower wages and slower technology adoption. UNCTAD (2017b) indicates that, for now, robot deployment has remained limited in manufacturing, especially in the textiles, apparel and leather sectors, which are particularly relevant to LDCs. Adjusting for adoption time lags reduces the estimates share of susceptible automation by half for Cambodia and Nepal.

Sources: Chang et al. (2016), MGI (2017), UNCTAD (2017b) and World Bank (2016).

Figure 4.6 Skill premium in selected Asian countries, percentage



Source: UNIDO (2016), p.114.

4.3.3 Capture of technology rents impacts inequality

Increasingly, the impact of technology on inequality has been associated with the generation of economic rents and rent-seeking behaviour. The economic rent (defined as excess income such as monopoly profits or unearned benefits emanating from preferential regulation) is not a new phenomenon. However, it is now argued that financial globalization, digitalization and the rise of frontier technologies are the enabling environments for rent-seeking that cause extreme, long-lasting and deepening inequality.[26] In the absence of global regulatory frameworks, globalization has accentuated the spread of digital companies and platforms as unregulated monopolies. These powerful monopolies influence the political process and tilt the rules in their favour, allowing them to capture a disproportionate share of the national income. Therefore, whenever a regulatory capture is allowed to persist, (extreme) inequality is not an unexpected unfortunate economic outcome, but rather a policy and governance failure to deal with the excesses of regulatory lobbying.[27]

Technology rent-seeking companies combine at least three types of rent sources. The first is linked to ownership of intellectual property, mostly patents.[28] The second is an ability to "force" customers to buy bundled products or services together, normally linked to the existence of monopoly power and high market concentration and coexisting with regulatory capture.[29] The third is network externalities, where consumers draw value from other consumers using the same product or service, such that the company that manages to get a critical mass of consumers tends to attract many more of them. The rise of online platforms (such as Alibaba, Amazon, Facebook, Google or Baidu) are perhaps the best example of network externalities.

Credit should be given to individuals and their talent and knowledge for making the digital world possible, but the extreme wealth based on rents should be shared with those who helped create it. While the knee-jerk reaction to a discussion concerning distribution is, in general, to impose taxes, a host of other policies can be effective in ensuring long-term fair solutions. Competition or anti-trust policies need to be the responsibility of an independent public entity to prevent it from capture by the vested interest groups. Furthermore, consumers might be given ownership rights to their own data streams, while those contributing to the creation of intellectual property (IP) should share royalty revenues. Labour laws could be revised giving more protection to workers, not jobs, so that they also benefit from the rents they generated.

To conclude, technology may drive income inequalities among countries, given the limited technological capabilities of LDCs, and between different types of workers given shifts in the nature of work, the skills-biased nature of technology and through the capture of rents.

4.4 TECHNOLOGY AND INEQUALITY OF OPPORTUNITIES

Under the right policy environment, the potential for technologies to reduce inequality in opportunities is vast. Technology innovation has contributed to major breakthroughs in providing the poorest with access to basic services. Solar home technologies have provided access to electricity to millions of households in Bangladesh, while providing job opportunities to 140,000 people.[30] Digital technologies have enlarged access to education and training, including to world-leading universities, through massive open online courses (MOOCs). Online e-commerce platforms have enabled small producers to sell their products worldwide and develop new markets in rural areas. In China, for example, more than 1,300 "Taobao villages" produce goods amounting to more than US$1.5 million each in annual trade.[31] In India, a technology-based financial inclusion system has provided financial access to 1.2 billion people in just six years (Box 4.2). Furthermore, technologies can support movements for democracy and social justice. The #metoo social media campaign against sexual harassment and assault has given a voice to women across the globe.

Technology offers considerable opportunities, but rewards are not guaranteed. For lower-income and other vulnerable groups to see benefits, research suggests that at least three conditions are necessary:

1) The availability of ICT infrastructure

ICT infrastructure is a prerequisite for knowledge-enhancing and content-rich applications, including online payments. Fixed-broadband Internet is required for more advanced applications. Inequalities in the availability of such infrastructure have widened as advanced countries developed rapidly (Figures 4.1 and 4.2).

2) Skills to identify and use technologies

Skills development is a second pathway to address growing inequalities, particularly in universities and institutes of higher learning (IHL).[32] Skills and knowledge acquired at IHL should be able to help address challenges associated with sustainable development, by providing applications and solutions focused on reaching the poor in remote rural areas and delivering services and information that narrow various forms of inequalities.

Examining the leading academic programmes of technology and computer science/engineering in five countries, namely Cambodia, India, Republic of Korea, Sri Lanka and Thailand, showed that some of the leading universities lacked affordable, reliable and adequate connectivity, which is the basis of science and technology education and research.[33] A lack of employment opportunities in Cambodia, for example, meant that ICT graduates were forced to work as taxi drivers. The study found that the required education goes beyond skills development and now encompasses cross-disciplinary, problem solving and critical thinking aspects, which are not widely available among the surveyed programmes. The ratio of women studying technology was found to be worryingly low – below 35 per cent in all surveyed countries.

3) Opportunities to access technologies that address the needs of low-income groups

Technologies available today do not necessarily respond to the needs of low-income and vulnerable groups. They are often developed by profit-seeking firms and naturally respond to the needs of more affluent markets. Policymakers can take multiple approaches that support the development of technologies and innovation solutions that respond to the needs of vulnerable groups, for example, the adoption of mission-oriented policies or system-wide transformations that address complex developmental challenges such as financial inclusion or renewable energy, financing social-problem research programmes or taking measures that promote grassroots innovations (Table 4.2).

Table 4.2 Approaches that promote technologies addressing the needs of low-income groups

Mission-oriented policies	**Examples**	**Characteristics**
Set of complementary policies and measures aiming to address complex society challenges	• Supporting financial inclusion in India • Transforming fuel-based energy systems towards renewable energy in China	• Aim to change the direction of technological systems • Focus on diffusion of technologies • Seek the development of radical and incremental innovations • Require leadership from the top, long-term investments and comprehensive policies
Grand challenge competition	**Examples**	**Characteristics**
Seek answers to intractable, complex and priority global health and development problems through crowdsourcing solutions.	• Water abundance XPRIZE[34]	• Incentivizes researchers, engineers or development agents to come up with concrete solutions • High upfront costs • Addressing the challenges may require regulatory changes beyond the sphere of influence of competition organizers
Social-problem research programmes	**Examples**	**Characteristics**
Research programmes that specifically search solutions to development problems	• Republic of Korea's social-problem research programme[35]	• Multi-departmental research projects driven by demand instead of supply • Require joint planning and implementation across different research departments • Require sound participation of civil society and citizens
Promotion of grass-roots innovations	**Examples**	**Characteristics**
Grassroots innovations are driven by groups typically excluded from the innovation process, through projects designed by local communities and/or inventions designed to meet specific local needs	• India's National Innovation Foundation[36]	• These innovations are driven by grass-roots organizations, but governments can also encourage them

Sources: Mazzucato (2017), OECD (2015)

Innovation activities, including the commercialization and transfer of technologies, and policies promoting the adoption and diffusion of technologies are important for ensuring that the poor benefit from technologies.

Market inefficiencies can, however, constrain access to existing solutions. An absence of local suppliers or a lack of access to credit are obvious barriers to the adoption of technologies. In agriculture, a lack of information on the benefits of certain farming techniques or market failures in land ownership – such as where lack of security of tenure undermines investment in irrigation – can all prevent agricultural technologies from being adopted.[37]

Innovative business and financing models that explore channels to reach the poor are vital. Large corporations have sought to reach poorer market segments through "bottom of the pyramid" business strategies that provide large-scale, low-cost and low-margin products, but their experiences have been mixed.[38]

One of the traditional roles of the public sector has been to address such market inefficiencies through incentives, regulations and support programmes. In the case of agriculture, these have included technology extension services that reduce informational inefficiencies; market development programmes or finance programmes that address the supply of credit.

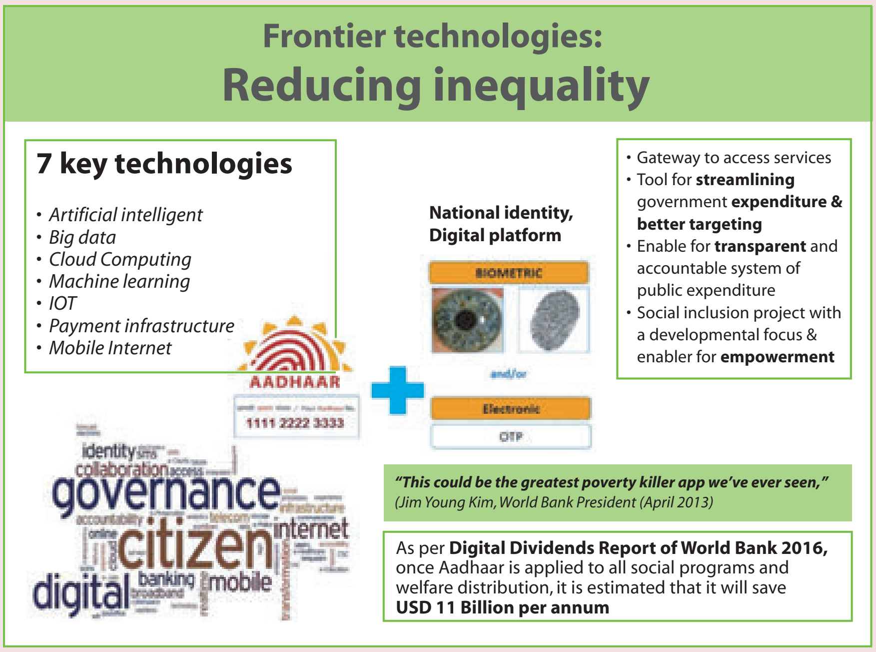
It is important to recognize that the state is not only a market fixer, it can also be a leader. Public policy action can support system-wide transformations that ensure that no one is left behind. Through public investment and procurement policies, governments can influence how technology is developed and diffused to address social challenges.[39] Several countries in the Asia-Pacific region have successfully introduced technologies that provide services to the poor on a large scale. India's technology platform based on Aadhaar biometric identification has, for example, revolutionized access to banking services (Box 4.2).

Box 4.2 Digital Aadhaar: financial services for 1.2 billion people in India

The world's largest digital ID programme, Aadhaar is a unique identification number based on biometric and demographic data issued to 99 per cent of Indian residents. It is linked to a mobile phone number and a low-cost (Jan Dhan) bank account, which facilitates the transfer of direct benefit schemes to the poorest and vulnerable in the fastest and most direct way. To provide incentives for people to use the Jan Dhan bank accounts, and thus for banks to eventually offer financial services to a wider range of citizens, the federal government and state governments are routing certain subsidies and salary payments through this platform. Almost 340 million people have now received direct benefit transfers, saving the Government an estimated US$7.51 billion over three years. As more people use Jan Dhan accounts, banks are piloting new digital financial services.

Key elements of the scheme's success have included: political support at the highest level, a large-scale and systemic approach, "buy-in" from capable private-sector suppliers and planning and building a simple, open, ubiquitous digital identity infrastructure. The project has nevertheless encountered several challenges. Some have been technical glitches and the limitations of the technology but perhaps of more importance has been the political challenge. The legal validity of Aadhaar, for instance, has been questioned on grounds of privacy and security.

Aadhar platform for financial inclusion and direct benefit transfers to the rural poor



Source: ESCAP and STEPI (2017)

4.5 TECHNOLOGY AND INEQUALITY OF IMPACT

The convergence of digital, space and other technologies, combined with advances in material sciences has helped reduce environmental inequalities and mitigate the asymmetric impact of environmental hazards, extreme weather events and disasters on the most vulnerable. Early warning services have proved particularly useful in that regard. Developed countries in the Asia-Pacific region are making great strides in harnessing frontier technologies to provide real-time, location-specific early warning information. AI interacting with high speed digital connectivity, now has the power to combine huge datasets and identify increasingly complex patterns. This data revolution greatly augments human understanding of evolving situations and helps policymakers prioritize actions. Similarly, thanks to innovations at the intersection of technology and science, early warning messages can be sent with ever-increasing lead times and accuracy in situations that cover both slow-onset and acute disasters.

A growing body of evidence is showing that innovative technologies can ease disaster-induced poverty and inequalities. Satellite-technology applications, for example, are helping countries with fragile ecosystems anticipate and respond to climate risks. In Mongolia, large geospatial datasets, disaggregated to district levels, are helping the authorities forecast droughts. By combining this information with detailed maps of poverty and livestock, by province and district, at a given time, it has been possible to identify those herders at highest risk of being affected by localized drought. The cost of mitigation actions such as additional livestock feed can also be calculated. Availability of such information has also helped mitigate the impact that such recurring disasters have on rural-urban inequalities. Other technologies also help anticipate and respond to climate change risks. For instance, in Tamil Nadu, India, traditional water harvesting techniques have been combined with biotechnologies that increase the tolerance of crops to the effects of climate change (Box 4.3).

Box 4.3 Tamil Nadu, India: a climate-risk hotspot

Tamil Nadu in India is exposed to various climate-related risks including cyclones, heavy rainfall, floods, droughts and landslides. The climate-risk assessments, based on high, medium, and low emission IPCC scenarios for the 2030s, 2050s, and 2080s, indicate persistent drought. Furthermore, increased rain at certain times of the year is likely to cause more intense flooding events in areas with increasing numbers of poor and vulnerable people.

Against these scenarios, policymakers have been encouraged to incorporate comprehensive climate-risk management into development planning. This comprehensive approach consists of an innovative mix of indigenous knowledge and advances in biotechnologies such as cultivation of drought-resistant crops.[40] Such applications enable increasingly accurate calculations of the impact of climate change on the agriculture sector with longer lead times.[41]

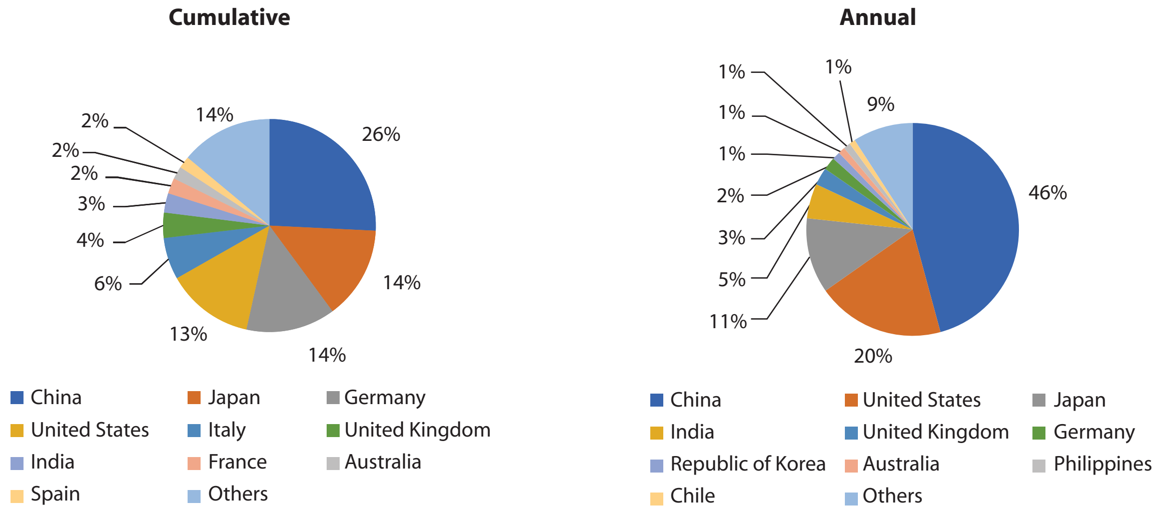
More specifically, traditional water harvesting techniques through percolating tanks have been combined with advances in biotechnologies that increase the tolerance of already drought tolerant crops to climate-change extremes such as increased average minimum and maximum temperatures, extreme heat events, flooding and increased salinity. Marker-assisted selection (MAS) techniques have been used on crops such as chickpeas and groundnuts that are important sources of nutrition in many drought-prone regions. With molecular breeding, a drought-tolerant chickpea variety has produced 10 to 20 per cent higher yield under increasingly variable weather conditions.[42]

Source: The Hindu (2016), Eisenstein (2013) and ESCAP (2015c)

The adoption of green technologies is also crucial to limiting air pollution and, given the disproportionate impact of air pollution on the poor (as discussed in chapter 3), to reduce inequalities of impact. For instance, China has made great strides in promoting the national solar industry to reduce the impact of air pollution, to respond to its growing energy needs and to support economic growth. As a result, China's solar photovoltaic (PV) industry has experienced a tremendous expansion since 2011, including significant growth in distributed energy.[43] By 2016, China had the largest installed photovoltaic capacity in the world, accounting for 25 per cent of the world cumulative capacity and contributing nearly half of world additional annual capacity (Figure 4.7). Chinese companies account for around 60 per cent of the world's annual solar cell manufacturing capacity.

The development of China's solar PV manufacturing has contributed to a steep reduction in the global cost of such technologies (between 2008 and 2015, the average cost of solar PV dropped by almost 80 per cent).[44] China's authorities are therefore supporting a global shift in power generation to renewable sources (including wind and hydropower), which will reduce the impact of air pollution for everyone. Nevertheless, coal

Figure 4.7 Installed photovoltaic capacity, top ten countries, 2016



Source: IEA (2017), 2016 Snapshot of Global Photovoltaic Markets.

still accounts for 66 per cent of China's primary energy supply.

Similarly, the Chinese Government is facing immense pressure to create jobs. While investment in renewable energy will help, job creation has not been enough to absorb the capacity cuts in the coal industry. In 2016 it reallocated 726,000 coal and steel workers, and in 2017 it had to reallocate half a million.[45] Finally, the lowering cost of PV solar technologies, has made investments in regions other than the economically poor, but energy-rich northern provinces, more attractive.[46]

4.6 CONCLUSIONS AND RECOMMENDATIONS

The relationship between technology and inequality is multifaceted. Technology has brought equality dividends by enabling productive transformation and rapid economic growth in a number of developing countries across the Asia-Pacific region. Technologies, notably ICT, have brought improved access to basic services such as finance and education, and are preventing and mitigating the environmental hazards that often disproportionately affect the poor. Technology has also widened inequality as countries differ in terms of investments, policy support or technological capabilities, or because technology is skill- and capital-biased and enables rent seeking, or because certain conditions need to be in place for vulnerable populations to benefit from technology, including ICT infrastructure, skills and access to appropriate technology solutions.

Frontier technologies, such as AI, are likely to intensify both the divides and the dividends. New technologies can create and reinforce inequality of outcome and opportunity with an implicit impact on the environment. Frontier technologies are likely to intensify these impacts because technological capabilities are not equally distributed across countries and people in the region. Particularly worrisome is the persistent digital divide in the region. Reliable and resilient broadband networks are often the foundation for developing and using frontier technologies such as AI. However, the lack of such broadband networks in many parts of the region means that AI uptake is and will continue to be uneven.[47]

The impact of technology on inequality is country-specific. Thus, measures aiming at ensuring that technologies do not exacerbate inequalities will vary. As a general guideline, more advanced countries, often early-adopters of frontier technologies, are advised to focus on managing the impact of technological transitions on inequality. The priority for countries with low levels of technological capabilities is to build their technological capabilities to spur economic growth. As countries accumulate technological capabilities, they would need to focus simultaneously on building stronger technological abilities, in particular technological skills, and increasingly on ensuring that technological progress does not translate into increased inequality. The following are the main thrusts of such policies.

1. Investment in ICT Infrastructure development

To address technology-induced inequality in the region, ICT infrastructure, notably broadband networks, must be affordable, reliable and resilient. Where progress has stagnated, such as in many LDCs and countries with special needs, a big investment push is needed. Without this investment in infrastructure there will be no narrowing of the existing digital divide and mitigation of the widening disparities.

2. Address persistent inequalities in technological capabilities

To catch up with more advanced economies, and thus reduce income inequalities among countries, countries with low technological capabilities should consider strengthening technological learning through public policies that should focus on the adoption, adaptation and diffusion of existing technologies rather than on investing in cutting edge R&D. Policies should aim to promote greater learning from trade and FDI, increasing productivity in existing productive sectors, and support the formation and growth of domestic firms, the absorptive capacity of domestic knowledge systems, productive diversification and export upgrading.

3. Promote regional and international cooperation to exploit technology dividends

ESCAP member States, regional and international partners, including donors, could prioritize funding for trans-border broadband infrastructure. In doing so, development can take advantage of existing infrastructure, such as trans-regional power grids, highways and railways. By making broadband infrastructure available in sparsely populated areas (the so-called last mile connectivity, where the business case is weak) the most effective use of government funds could be made in reducing digital inequalities and its knock-on effects on a range of inequalities.

In an effort to increase the availability of affordable broadband connectivity for all, ESCAP has been supporting its member States and partners in the region for the implementation of the Asia-Pacific Information Superhighway (AP-IS).

Regional cooperation platforms can also be helpful in the exchange of expertise and knowledge services that reduce capacity inequalities among countries. For example, ESCAP's well established Regional Space Applications Programme (RESAP) has promoted the exchange of tools between advanced space-faring countries and low capacity, but high disaster risk countries.

As part of the 2030 Agenda, governments have committed to fostering technology development, dissemination and transfer and to the strengthening of scientific and technological capabilities of all countries and have agreed to put in place two global mechanisms: the United Nations Technology Facilitation Mechanism and the United Nations technology bank for LDCs. The implementation of such mechanisms have taken a slow start, largely because of a lack of financial resources, and will require further support from more advanced economies.

4. Anticipate the impact of technologies on jobs and wages

Technology changes may transform the composition and nature of work. Reducing income inequalities within countries requires seeking economic growth paths that minimize the impact of technologies on those in fragile job situations. Policymakers need to anticipate the specific changes that are likely to take place. This preparation requires, for instance, more detailed sectoral studies on which tasks are more likely to be replaced by technology, how labour and wages will be impacted, and the nature of re-skilling that would allow displaced workers to transition to new jobs.

There is also a need to consider the implications for the education sector and ensure that it is better equipped to build the skills required for current and future work. Education policies are the foundation for building technological capabilities and a fundamental element for addressing inequalities of opportunity. However, enhancing human capital is necessary but not sufficient to make economies more inclusive. Social protection policies will also be required to mitigate the impact of labour-replacing technologies (as discussed in chapters 1 and 2).

5. Address technology rents to mitigate their impact on extreme inequality

Taming technology rents and rent-seeking is critical to reining in inequality. However, technology per se is neither the problem nor the solution. Policymakers need to address the conditions that have allowed extreme accumulation of wealth, including enforcing competition laws, strengthening intellectual property protection and bargaining power of workers and consumers.

6. Introduce more inclusive technology and innovation policies

Inclusive technology and innovation policies can help address inequalities. While the market is a key determinant of technology development, governments have influence in the direction of technology change.

Governments can lead with mission-driven policies or system-wide transformations to address a national social or environmental priority. Mission-driven policies are complex endeavours that require leadership from the top, long-term investments, and comprehensive and coherent policies from the supply and demand-side that support the development and adoption of technologies. These are likely to be best suited to high and middle-income economies with solid public-sector capabilities.

Governments may also introduce targeted technology and innovation programmes that address the specific needs of vulnerable populations, such as public research programmes that specifically seek solutions to development problems or the promotion of grassroots innovations.

The governance of technology and innovation policy processes matters for equality. In lower-income countries, governments are advised to give due priority to the building of domestic technological capabilities and, accordingly, allocate the corresponding budget funds. In more advanced economies, there is a need for governance models to integrate and coordinate technological and innovation policies with other economic and social policies and to give voice to a wide range of agents throughout the policy cycle.

ENDNOTES

1 United Nations, Department of Economic and Social Affairs (DESA) (2015).

2 The most promising and potentially the most disruptive emerging technology trends are, according to (OECD, 2016b): big data, the Internet of Things, artificial intelligence, additive manufacturing, nano/microsatellites, neurotechnologies, synthetic biology, nanomaterials, advanced energy storage technologies and blockchain. All these frontier technologies are dependent on digital infrastructure.

3 The 18 countries referred to are: Afghanistan, Cambodia, Fiji, India, Indonesia, Kiribati, Lao PDR, Marshall Islands, Myanmar, Nepal, Pakistan, Papua New Guinea, Samoa, Solomon Islands, Tajikistan, Timor-Leste, Turkmenistan, and Vanuatu. See United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2017e).

4 See, for example, data provided by ITU (2017).

5 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2017e).

6 Metcalfe and Ramlogan (2008)

7 For a summary of methodologies see Reamer (2014)

8 Violante (2016)

9 Comin (2006).

10 For an overview on current discussions on measuring productivity see OECD (2016a).

11 See Kingston, (2001); Kozo and Yasukichi (1987); UNIDO (2016); Shi, (2010)

12 See, for instance, Cirera and Maloney (2017), United Nations Conference of Trade and Development (UNCTAD) (2017a) and UNCTAD (2007).

13 Rodrik (2015)

14 The use of software applications in drafting a design, data analysis, accounting are some examples of technology complementing workers.

15 See, for example, Arntz et al. (2016); Bessen (2015 and 2017); Graetz and Michaels (2015); Lawrence (2017); Ugur and Mitra (2017); Vivarelli (2014).

16 Jobs for high-skilled workers and low-skilled workers have still not been economically feasible to be automated in a large scale. High-skilled jobs often involve non-routine cognitive tasks (such as managerial tasks and technical specialists). Low-skilled jobs are manual tasks, many of which are non-routine (such as gardening and babysitting). Automating low-skilled tasks in a large scale has also not been economically feasible due to relatively low cost of labour in this segment.

17 See, for example, Arntz et al. (2016); Bessen (2015 and 2017); Graetz and Michaels (2015); Lawrence (2017); Ugur and Mitra (2017); Vivarelli (2014).

18 Shih (2013).

19 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2018g).

20 UNCTAD (2017b).

21 See HBR (2017) and PWC (2018).

22 See, for example, PWC (2017) and MGI (2017b).

23 MGI (2017a).

24 Data retrieved from https://public.tableau.com/profile/mckinsey.analytics#!/vizhome/AutomationBySector/WhereMachinesCanReplaceHumans.

25 UNIDO (2016).

26 Rent-seeking entails capturing wealth produced by others (rather than by generating any actual economic activity) (Krueger, 1974). An example is lobbying Government to obtain a subsidy.

[27] "Over the past few years, Big Tech has quietly become the dominant political lobbying power in Washington, spending huge amounts of cash and exerting serious soft power in an effort to avoid regulatory disruption of its business model, which is now the most profitable one in the private sector. According to the Center for Responsive Politics, the internet and electronics industry together spent a record US$181m on federal (US) lobbying in 2015 and US$178.5m in 2016, making them the second-largest corporate lobbyist, behind Big Pharma. Alphabet, Google's parent company, is now the tenth-largest individual corporate spender in the country." (Foroohar, 2017).

[28] Patents, while established to serve as an incentive for innovators to innovate, they also prevent others from innovating. Some firms use aggressive patent strategies (such as aggressive litigation, aggressive patenting, acquisition of start-ups merely for their patents), to maintain a monopoly situation and prevent competition.

[29] De Loecker and Eeckhout (2017) argue that the increase in market power (in the US) is consistent with the decline in the labour and capital shares in income, declining wages for low skilled labour, decreases in labour force participation, flows and inter state migration rates, as well as lowering GDP growth.

[30] See United Nations Conference of Trade and Development (UNCTAD) (2017a) and http://www.daily-sun.com/printversion/details/198809/Bangladesh-seeks-IRENA%E2%80%99s-support-for-renewable-energy-dev

[31] AliResearch (2016).

[32] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2017e).

[33] Ibid.

[34] Mitchell et al. (2014)

[35] ESCAP and STEPI (2017).

[36] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2016b).

[37] Jack (2013).

[38] Simanis (2012).

[39] Mazzucato (2013).

[40] *The Hindu* (2016).

[41] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2015c).

[42] Eisenstein (2013).

[43] The 12th Five-Year Plan (2011-15) already supported the development of the photovoltaic capacity.

[44] OECD/IEA (2016d).

[45] Reuters (2017).

[46] Zhou and Lu (2017).

[47] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2017e).