

# Financing for Sustainable Development Report 2019

Inter-agency Task Force on Financing for Development



United Nations

This report is a joint product of the members of the Inter-agency Task Force on Financing for Development (a full list of members can be found on page x). The Financing for Sustainable Development Office of the United Nations Department of Economic and Social Affairs serves as the coordinator and substantive editor of the Financing for Sustainable Development report.

The online annex of the Task Force (<http://developmentfinance.un.org>) comprehensively monitors progress in implementation of the Financing for Development outcomes, including the Addis Ababa Action Agenda and relevant means of implementation targets of the Sustainable Development Goals. It provides the complete evidence base for the Task Force's annual report on progress in the seven action areas of the Addis Agenda (chapters III.A–III.G). The report is by necessity more concise and selective and should thus be read in conjunction with the online annex.

The online annex also covers several key cross-cutting initiatives that build on the synergies of the Sustainable Development Goals:

- Delivering social protection and essential public services
- Ending hunger and malnutrition
- Closing the infrastructure gap
- Promoting inclusive and sustainable industrialization
- Generating full and productive employment for all
- Protecting ecosystems
- Promoting peaceful and inclusive societies
- Gender equality
- Investing in children and youth
- Addressing the diverse needs and challenges faced by countries in special situations
- Global partnership

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SCIENCE, TECHNOLOGY,  
INNOVATION AND  
CAPACITY-BUILDING





## Chapter III.G



# Science, technology, innovation and capacity building

## 1. Key messages and recommendations

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Rapid changes in new and emerging technologies have great potential to support achievement of the Sustainable Development Goals (SDGs), but also raise new challenges. Yet, institutions and policy and regulatory frameworks at the national and international levels have not kept pace with these changes.

Recent developments in automation have raised concerns that rapid advances in artificial intelligence (AI) and other technologies could make the labour of millions in developed and developing countries redundant. While estimates are highly uncertain, there are several actions Governments can take to be better prepared: *encourage innovation that uses technologies to create new products, services, and jobs; be sensitive to the differential impact on women and men; ensure social protection and extend social security mechanisms to compensate for loss of working hours and jobs; and invest in people's capabilities in order to enable them to benefit from new technologies, with attention to the different needs of different groups (young, older, persons with disabilities, women, men and others).*

Advances in access to mobile Internet, cryptography and distributed computing have given rise to financial innovations (fintech) that has fostered financial inclusion. However, they also led to new risks and challenges for financial markets. Regulation needs to address these risks without stifling financial innovation. *Improved dialogue between policymakers, regulators and new service providers is critical to finding the right balance. Governments should incorporate platforms for dialogue into their policy frameworks. Experimentation and innovative mechanisms, such as regulatory sandboxes, can help policymakers design appropriate regulatory frameworks.* Given that new actors involved in fintech are blurring the lines between software, settlement and financial

intermediation, *financial regulators will need to shift from looking at the type of financial institution providing financial services, to the underlying risks associated with the financial activity.*

Developing countries need support from the international community to close technology gaps and address digital divides, keep up with rapid technology change, and make progress towards the SDGs. A variety of factors can constrain diffusion of technology. *To improve access, it is important to identify binding constraints—be they absorptive capacities and the digital skills gap, lack of economic incentives, social and cultural factors, or issues related to intellectual property rights (IPRs). International organizations can help in this endeavour and international cooperation can contribute to address obstacles in each of these areas.* Because the technology landscape is evolving rapidly, facilitating access to relevant technologies requires policy experimentation. The increasing digitalization and connectivity of the economy exemplifies this continuous change; it makes entirely new innovation approaches possible, but also raising new challenges, especially for the poorest countries.

## 2. New and emerging technologies and the Sustainable Development Goals<sup>1</sup>

New and emerging technologies are characterized by rapid development<sup>2</sup> and the possibility of their combination based on digitalization and connectivity.<sup>3</sup> Several new technologies show potential

to help achieve many of the SDGs. However, to benefit, countries will need to strengthen technology capabilities and increase access for all groups in a wide range of areas, with support from the international community.

Advances in information and communications technologies, which have vastly increased digital interconnectedness, are at the heart of this technological change. They have spurred innovations such as big data, AI, 3D printing, Internet of things (IoT), robotics, cloud computing and many others.

Big data can lead to scientific breakthroughs, advances in human health and improved decision-making and effectiveness of development interventions. The Internet of Things (IoT) monitors and manages connected objects and machines and has applications in health-care, agriculture, energy, and water management and quality.<sup>4</sup> AI offers a wide range of capabilities including image recognition for diagnostics in health care, and agriculture. Combined with robotics, AI could transform production and distribution networks, in line with new business models, especially in manufacturing.<sup>5</sup> New types of 3D printing<sup>6</sup> allow ever faster and cheaper low-volume production and rapid iterative prototyping of new products,<sup>7</sup> offering benefits in healthcare, construction and education.

Biotechnology makes possible the personalized treatments and genetic modification of plants and animals.<sup>8</sup> Nanotechnology is used in water purification, battery storage, precise management of agrochemicals, and in the delivery of medication.<sup>9</sup> Renewable energy technologies provide electricity in rural areas far from the grid systems,<sup>10</sup> while drones are used in precision farming and could revolutionize the delivery of supplies and replace humans in dangerous tasks.<sup>11</sup> Small-scale satellites are used in communication networks and in applications that use high-resolution imagery in areas such as for monitoring land use and for urban planning. These satellites may soon become affordable for more developing countries, businesses and universities.<sup>12</sup> Blockchain technology can be used in applications in which ensuring the integrity and traceability of the information about transactions is important, such as those in smart contracts, digital identity systems, land registration, and financial transactions.

Many developing countries are already using these technologies, even in conditions of low resources and capabilities.<sup>13</sup> For example, during a typhoid outbreak in Uganda, the Ministry of Health used data-mapping applications to allocate medicine and mobilize health care teams.<sup>14</sup> In India, the CropIn start-up has developed a vegetation index using satellite images that provides support to farmers in ensuring crop health.<sup>15</sup> In Bangladesh, IoT is being used to assess groundwater chemistry and protect the people in the Ganges Delta who face the threat of drinking groundwater contaminated with arsenic.<sup>16</sup> In Rwanda, the Government partnered with Zipline, a robotics company, to address maternal mortality by using drones to deliver blood to medical facilities, reducing the time it takes to procure blood from 4 hours to 15 minutes.<sup>17</sup>

As new technologies are becoming cheaper and easier to access and use, many new applications that support progress towards achieving the SDGs become possible. At the same time, gaps continue to persist both within and between countries, including in the access to digital services, and there are risks of existing inequalities being exacerbated. Societies also need to manage the often significant social, economic and environmental consequences of rapid transformations brought about by technologies (see, for example, box 1).

## Box 1

### New technologies and education

Artificial Intelligence (AI) and related technologies can support new forms of quality education and lifelong learning (SDG 4) and offer more flexible, lifelong learning pathways.

Part of the challenge surrounding AI is an incomplete understanding on its implications for education systems and practices and, in particular, which human skills need to be developed to ensure that humans benefit optimally from AI-powered machines. This is particularly pressing in developing countries where young people often lack job-ready skills and AI platforms, tools, and applications are scarce. In the least developed countries (LDCs), a lack of mass digitalization and low penetration of broadband mean there is insufficient data for machine learning and deep learning. There is also a lack of transparency in the use of education data to ensure algorithmic accountability, privacy and data transparency.

In response, “AI for Education- Harnessing AI to Achieve SDG 4”, a UNESCO initiative, aims to: strengthen capacities of policymakers; promote AI literacy programmes in school curricula and lifelong learning; enhance training for teens and young people (with a priority on girls and women), and to advocate for transparent and auditable use of education data.

Source: UNESCO.

## 3. New technologies and labour markets

Recent progress in automation and AI has contributed to a rising fear of technology driven unemployment. Robots and smart machines are able to replace workers in ever more complex tasks, such as those that require visual inspection and classification. They have slowed employment growth in both developed and developing countries. Thanks to advancements in AI and the autonomous processing of large swaths of data, an increasing number of sectors are affected, including those that

provide services such as medical and legal assistance, accounting and credit analysis. Education and skills, once a guarantee for secure employment in many countries, no longer necessarily provide the expected benefits of relative wages and job stability.

The overall impact of digital technologies on employment remain uncertain, but recent estimates point to a high probability of considerable labour market disruption. For example, estimates of future job losses due to automation and AI range from a low of 5-10 per cent to almost half of all existing jobs. Research also differs on the expected impacts on different groups, such as women and men, of these changes. In developing countries, two thirds of all jobs might be at risk of automation and AI.<sup>18</sup> According to some surveys, the resulting rise in unemployment rates could reach more than a quarter of the labour force by 2050.<sup>19</sup> Developing countries might be most affected because of their greater distance from the technological frontier and the impact of automation on patterns of production and trade specialization and opportunities for catch-up.<sup>20</sup>

So far, the widespread introduction of digital technologies has not led to a rise in overall unemployment but may have contributed to rising income inequality and job polarization (see last year's Task Force report). Productivity growth has shown no signs of acceleration, a phenomenon dubbed the "productivity paradox".<sup>21</sup> To date, only a few firms are reaping most gains provided by new technologies, in part because adoption rates remain low in many parts of the world.<sup>22</sup>

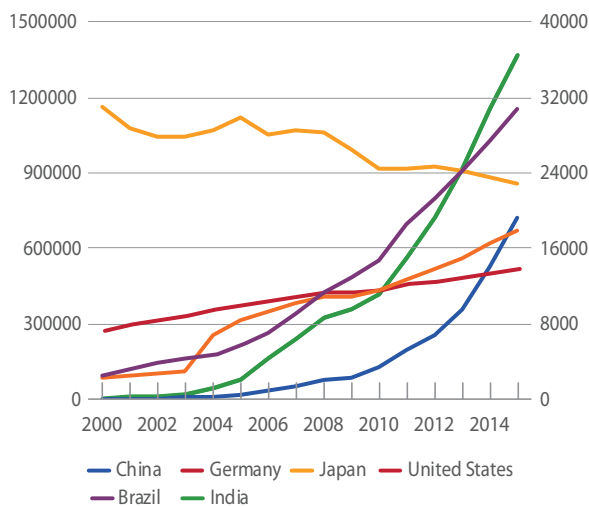
New technologies should also lead to the creation of new jobs, which was the pattern of previous technological revolutions. For example, AI is good at predicting on the base of past patterns. It could displace workers that provide these services but could also create new demands for skills that take advantage of cheaper prediction as an input for decisions that still require human judgement. However, it is difficult to predict in which sectors employment will be created, and the complementary skills that will be required. Advanced cognitive skills, such as in science, technology, engineering and mathematics (STEM) fields, and inherently human skills and aptitudes are likely important, as they are difficult for algorithms and machines to emulate.<sup>23</sup> So far, many displaced workers have often found jobs outside their traditional occupation, but often at lower wages. New digital technologies also carry potential to improve provision of services at a higher quality and with decent work standards. This could prove particularly important for care activities, which are often female-dominated, and where there is significant unmet demand.<sup>24</sup>

### 3.1 Automation: challenges for jobs in developing countries

In recent decades, automation has made the largest inroads through the use of robots, i.e. re-programmable, multi-purpose and automatically controlled devices. The stock of robots has expanded across the world, most

dramatically in China, and has affected countries at all income levels (figure 1).

Figure 1  
Robot stock in selected countries, 2000-2015  
(Number of robots, ratio)



Source: International Federation of Robots.

Note: The chart displays the number of robots in selected economies. The number of robots in Brazil and India are displayed on the right-hand side scale.

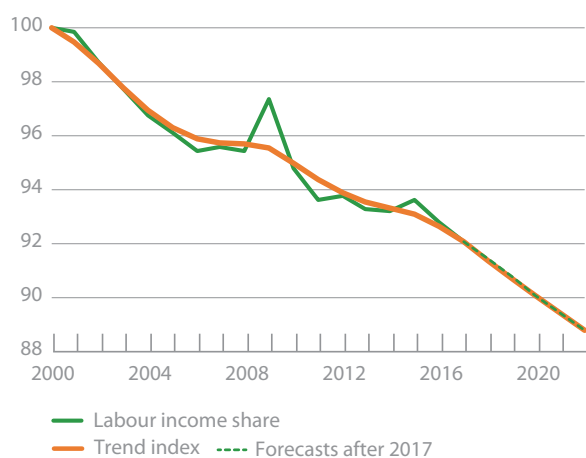
Robotization has already negatively impacted global employment growth, with pronounced effects in emerging economies.<sup>25</sup> Between 2005 and 2014, employment losses due to robotization were almost 14 per cent in emerging economies compared to 0.5 per cent due in developed countries, with the most notable losses in industrial employment. Technologically-driven declines in incentives for off-shoring—and in some cases re-shoring of industrial activities—depressed employment in emerging economies by 5 per cent.

Manufacturing exports—a historic engine of employment creation in developing countries—have become less labour-intensive in both developed and developing countries.<sup>26</sup> Price reductions prompted by new technologies have benefitted both consumers and producers—mobile phones and banking have increased productivity for a range of activities and created jobs. However, to the extent that new technologies require highly skilled labour there is evidence that they may be less complementary with existing capabilities in developing countries.<sup>27</sup>

Policymakers can consider several options to boost employment creation. First, there is still a window of opportunity to pursue policies that lead to job creation in activities not yet automated, or where automation in developed countries will not be cost-competitive with production in developing countries for several decades.<sup>28</sup> Second, the reduction in capital costs brought about by new forms of automation, such as applications of AI, may support significant technological upgrading. Big international players such as Google have started

tapping into this market, opening research centres in low-income countries.<sup>29</sup> Some of these activities are tradeable, particularly services in information technology and finance. Because some of the technologies are *complementary* to unskilled labour (e.g. matching applications such as ride-hailing services), which is abundant in developing countries, they are a potential source of new employment opportunities in those countries.<sup>30</sup> Third, to ensure competitiveness in the long-run, these efforts should be complemented by investments in the digital economy to build digital capabilities.

Figure 2  
Global labour income share, 2000-2020  
(Index)



Source: ILO, Global Wage Database, 2018; ILO, Wage projection model.

### 3.2 Shifting wealth, growing concentration of production and profits

Automation has led to a high concentration of profits among a few companies and locations<sup>31</sup> contributing to growing inequality. A few frontier technology firms have reaped a large share of the recent productivity gains and profits, a trend that predates the global financial crisis.<sup>32</sup> Digital technologies have also led to increasing labour market concentration, with workers facing fewer opportunities for mobility and reduced bargaining power, including in online platforms.<sup>33</sup> As a consequence, the labour income share has continued its long-term decline (figure 2)<sup>34</sup> and income inequality within countries has risen (see chapter I).

### 3.3 How can decent work be achieved?

Policymakers can promote new technologies in areas where large unmet demand for (mostly) socially relevant activities remains, such as in personnel and health care. Public policies should encourage the use of new technologies that also offer opportunities for new jobs. This needs to be accompanied by extending regulation and social security mechanisms in order to prevent private providers undercutting existing protection schemes.<sup>35</sup>

Investments in peoples' capabilities also needs to be increased. Digital divides need to be addressed, including by supporting all workers to develop the digital and complementary skills needed in the digital age. The International Labour Organization's *Global Commission on the Future of Work* proposed a universal entitlement to lifelong learning that enables upskilling and reskilling, to enable people to benefit from new technologies and new work tasks.<sup>36</sup> One example is adult learning for women during family related absences from work, such as care-related events.

As the world of work reorganizes and part-time employment and underemployment rise, social protection needs to expand its focus to include compensation for loss of (market) working hours, not only for loss of jobs.<sup>37</sup> This requires shifting the debate on achieving decent work from a focus on "full employment" to a focus on "full activity" in achieving decent work.

## 4. Fintech and financial inclusion

Digitally enabled innovation in the financial sector (fintech) is changing the shape of financial systems. Fintech has contributed significantly to the rapid expansion of access to financial services and financial inclusion. It has helped Governments reduce operational costs and more effectively deliver transfers to citizens. It has made low cost, prepaid or pay-as-you-go business models viable in sectors such as energy and thus enabled progress on the SDGs. Its impacts are visible across the 2030 Agenda for Sustainable Development.

Advances in AI and computing power allow extraction of more value from rapidly growing data and are transforming credit decisions. Ever wider mobile access to the Internet has fueled the mobile money revolution. Advances in cryptography and distributed computing have given rise to digital currencies, smart contracts and new forms of biometric identification.

New financial products can carry many traditional financial risks, such as credit risk, liquidity risk, and asset liability mismatches. But the entry of new fintech actors, instruments and platforms has helped to ameliorate some market imperfections that are pervasive in the financial sector, such as incomplete or asymmetric information, high transactions costs, and high barriers to entry for new providers.

Fintech can facilitate more speedy, secure and transparent service delivery. It has enabled innovations ranging from new credit, deposit and capital-raising services (e.g., crowdfunding, lending marketplaces, mobile banks) to payment, clearing and settlement services (e.g. mobile wallets, digital currencies) and investment management services (e.g., high-frequency trading). Table 1 provides examples of new technologies and the innovation in financial services they have facilitated.

At the same time, fintech affects service providers themselves, and the market structure of the financial

Table 1  
New technologies and impact on financial services and providers (examples)

	Credit, deposit	Payment, clearance	Investment management
<b>Artificial intelligence, big data</b>	Automated credit decisions, crowdfunding	Fraud detection	Investment advice, high frequency trading
<b>Distributed computing</b>		Payment settlements, back-end processing of payments	
<b>Cryptography</b>	Identity protection	Identity protection	
<b>Mobile Internet access</b>	Mobile money, crowdfunding	Mobile money	Digital wallets

Source: Based on IMF, 2017

system. New providers, often originating outside the financial sector, are challenging traditional business models. They include mobile money providers, e-commerce giants and marketplace lenders. As new technologies alleviate information failures and reduce transaction costs, traditional intermediaries such as banks, whose business proposition is in part to overcome these market failures, could be at risk of being displaced.<sup>38</sup> This in turn creates challenges for regulatory systems that have traditionally focused on regulating by type of entity.

Fintech innovations thus create new opportunities and new risks and challenges for consumers, service providers and regulators. It impacts all key objectives of financial policy makers, such as access and inclusion, but also consumer protection, financial integrity, competition, and financial sector stability and its ability to promote growth and sustainable development.

## 4.1 Enhancing financial access

More than half a billion people opened an account and gained access to financial services between 2014 and 2017 (see chapter III.B.),<sup>39</sup> in large part due to the growth of fintech. In sub-Saharan Africa, 21 per cent of adults now have a mobile money account. In India, issuance of biometric identification cards contributed to rapid growth of account ownership (box 2). Inclusive digital financial services helped lift about 1 million people out of extreme poverty between 2008 and 2014 in Kenya, with a particularly strong impact on female-headed households. Farmers are managing risks and making investments that result in higher yields and incomes.<sup>40</sup> There is also some early evidence that mobile money might help to close the gender gap in account ownership, which remains sizeable, at 7 percentage points globally.<sup>41</sup>

The picture is not uniform across countries. Mobile money has made a significant impact in some countries outside of sub-Saharan Africa, such as Bangladesh and Mongolia, but this is not reflected in broader global trends (only 1 per cent of adults rely on a mobile money account alone globally). Fintech remains a nascent industry in Latin America and the Caribbean, mainly concentrated in Brazil and Mexico, and to a lesser ex-

tent in Argentina, Chile and Colombia. Even in Africa, the share of adults with mobile money accounts varies widely between countries. To a degree, this points to the continued digital divide across and within countries. Often, however, it reflects shortcomings in regulatory environments. It also reveals the potential for digital technologies and mobile money have to close the remaining access gap.

Of the 1.7 billion adults in the world that do not have access to financial services, about 1.1 billion have a mobile phone. Mobile phones could continue to strengthen financial inclusion, provided the necessary complementary investments and policy actions are made. They include infrastructure investments in reliable electricity and network connections, and in payment systems and other financial infrastructure. They also include an enabling regulatory environment. Licensing for non-bank providers to issue mobile money, permission to use third-party agents for service provision, risk-based and proportionate customer due diligence standards, and effective consumer protection have emerged as necessary regulatory conditions for digital financial services to spread.<sup>42</sup> Social, economic and cultural factors also have an impact on who can gain access and need to be addressed. In addition, policymakers can lever the public sector's own transfer payments to enhance access—digitizing public sector transfers, pensions and wages and utility bills has contributed to increased account ownership in several countries.<sup>43</sup>

## 4.2 Fintech and small and medium-sized enterprises

Fintech might also help close the financing gap faced by small- and medium-sized enterprises (SMEs). SMEs are a major source of growth and job creation. Surveys indicate that lack of access to finance is a major obstacle for SMEs in many developing countries (see chapter III.B).

SME financing challenges relate to both demand and supply-side issues. The former can include cumbersome financial documentation and collateral requirements, slow applications and high interest rates. On the supply side, the lack of credit history or more general information, low revenues per client, and high levels of SME



informality impede lending to SMEs.<sup>44</sup> Digitalization can address some of these impediments. The fast growing digital footprint of SMEs—which create data whenever they make or receive digital payments, buy or sell electronically, use cloud-based services, or get rated online—can help overcome information constraints. Thanks to advances in computing power and smart algorithms, this more diverse data can increasingly be translated into reliable determination of creditworthiness, at a falling cost and at much higher speed. While these advances do not eliminate small business risk per se, they do create more viable business models in this market segment for both traditional and new lenders.

New fintech lenders include large e-commerce and payment firms, such as Amazon and PayPal in the United States of America or Baidu and Tencent in China. Access to the transaction history of their users puts them in a position to assess credit risk. Because of their vast scale, they have the potential to become significant providers of financial services.<sup>45</sup> Fintech companies have also started to offer supply chain financing, and mobile lending models offer small mobile loans based on mobile e-money usage and savings and credit history.

Online platforms and marketplace lenders are intermediary platforms. They offer fast loan applications, but shorter-term loans than traditional banks. Thanks to big data and smart algorithms, they can provide automated credit screenings as they connect lenders and borrowers. The peer-to-peer label is sometimes misleading, however, as loans are also funded from their own balance sheets or from investors.

Fintech is also increasingly a priority for traditional lenders. They possess a growing amount of information and data on their SME clients, but data silos and legacy systems have meant that many banks are not using this data to its full extent in lending decisions. Some banks have perceived fintech companies, particularly those intermediating credit, as a threat to their business models. Fintech companies are often more nimble in reaching new clients and storing data, and are often outside the regulatory umbrella (see chapter III.F). At the same time, many traditional financial institutions have started to engage and partner with fintech companies to update their data analytics and mobile technology and to explore new technologies such as blockchain.<sup>46</sup> Over 80 percent of top global banks have some form of partnerships with fintechs. In some cases, digital lending tools have brought down “time to cash” for small business lending from an average of 3 months to less than 24 hours.<sup>47</sup>

### 4.3 Balancing access with consumer protection, integrity and stability

Enhancing the breadth and depth of the financial system needs to be balanced with safeguarding consumer interests, financial integrity and system stability. These objectives are mutually reinforcing; effective consumer protection and financial system stability are enablers of greater financial inclusion, and a more stable financial system in turn supports investments in sustainable

development. However, there can also be trade-offs, as a quick scaling up of new technologies can lead to consumer fraud on the one hand, as well as risks of excessive leverage in unregulated areas of the economy (e.g., through shadow banking), which has been at the root of many financial crises over the past decades. As new financial products and actors enter the financial system, policy and regulatory responses have to adapt to these new circumstances and carefully manage risks of fintech, without stifling innovation and destroying opportunities for achieving the SDGs.

Consumer protection has arisen as a concern around mobile money, with relatively high levels of fraud in some major markets. Identity theft, false promotions or phishing schemes, agents defrauding customers, or agents that were themselves defrauded have all been reported.<sup>48</sup> As noted in last year’s Task Force report, over half of all consumers in one major African market experienced fraud; and exposure was high in other markets as well. At the same time, levels of fraud differ greatly between countries, which indicates that this risk can be mitigated. Country experiences suggest that effective consumer protection requires first and foremost that regulatory regimes cover all providers. Additional factors include measures to enhance transparency, such as disclosure requirements on fees in a standard comprehensible format; opportunities for consumer complaints; enforced and costly penalties for bad behavior; minimum standards for digital platform reliability; and mechanisms to correct mistaken or fraudulent transactions.<sup>49</sup>

Crypto-assets or digital currencies carry widely reported risks for consumers and investors. In addition to price volatility, providers offering services for crypto-assets, such as wallet providers and exchanges, are not covered by traditional safeguards such as deposit insurance. Bankruptcies and fraud have caused major losses for consumers. Initial coin offerings (ICOs)—where companies raise capital by creating digital assets related to a specific product or business model—have gained in popularity, with about \$7 billion raised in the first half of 2018. However, an often-cited study has found that over 80 per cent of ICOs to date were ultimately identified as scams.<sup>50</sup> In response, regulators in several countries have started to apply investor protections to ICOs.

Fintech also impacts financial integrity, including anti-money laundering and countering the financing of terrorism (AML/CFT) goals. There is evidence that crypto-assets have proven fertile ground for financial crimes.<sup>51</sup> In October 2018, the Financial Action Task Force (FATF) updated its standards and recommendations regarding cryptocurrencies. It defined a new group of “virtual asset service providers”, such as cryptocurrency exchanges, wallet providers, and providers of financial services for ICOs, and called on jurisdictions to include virtual asset service providers in AML/CFT regulations.<sup>52</sup>

Nevertheless, fintech also provides opportunities to overcome AML/CFT-related barriers to access to

## Box 2

## India: the JAM trinity

The JAM (Jan Dhan, Aadhaar, Mobile) trinity is an ambitious, technology-driven initiative to promote financial inclusion in India by linking universal biometric digital identity (Aadhaar), government-sponsored bank accounts (Jan Dhan), and mobile numbers. It creates a low-cost and accessible financial infrastructure supporting services previously out of reach for most Indians.<sup>a</sup>

The first pillar of the trinity is the Aadhaar, a unique identification (ID) number based on demographic data and biometric information collected from fingerprints and iris recognition. It enables easy identification for accessing public and private services and offers fraud protection. Since its introduction in 2009, about 1.2 billion ID numbers have been issued, making it the largest database of its kind in the world. The second element is the Jan Dhan, a low-cost bank account that provides benefits such as no minimum balance requirement, debit cards (RuPay), inexpensive life and accident insurance, access to government subsidies and affordable loans. Since the beginning of this project in 2014, a total of 326 million accounts have been opened totalling almost \$11.7 billion. The third pillar is the mobile number, which provides the 1.16 billion of mobile phone subscribers (of which 463 million are connected to wireless broadband) with access to virtual services anywhere with network accessibility.

Building on these three interconnected databases, the Government and its partners have created a national digital infrastructure called India Stack. It is an ecosystem of open application programming interfaces that enable governments, businesses, startups and programmers to develop innovative financial and non-financial services.<sup>b</sup>

In its few years of operation, the initiative has already brought positive impacts and saved the government \$8.1 billion. By using a biometric digital ID, public services are more likely to reach the right people, reducing leakage. The Aadhaar Payment Bridge (APB), for example, allows the Government to send liquified petroleum gas subsidies directly to the beneficiary's unique Aadhaar ID.

Nonetheless, the JAM trinity has also faced challenges. One concern regards the ownership of personal data and recourse to its possible misuse. Another issue is the potential impact on inequality. In response, the 2016's Aadhaar Act states that no one should be denied public services for not having an Aadhaar ID. A third concern was tax avoidance. The policy response was to instead try to use the information from Aadhaar to strengthen tax compliance. A recent Supreme Court ruling upheld an executive decision obliging Aadhaar holders to link it to their income tax Permanent Account Number card.

Source: ESCAP.

<sup>a</sup> United Nations Economic and Social Commission for Asia and the Pacific, *Innovative Financing for Development in Asia and the Pacific: Government Policies on Impact Investment and Public Finance for Innovation* (Bangkok, 2017).

<sup>b</sup> For more information, see the website of IndiaStack, available at: <http://indiastack.org>

financial services. In many cases, cross-border payments are costly, slow and opaque, without transparent pricing. These challenges have been exacerbated by de-risking and reductions of correspondent bank relationships related to AML/CFT concerns (see chapter III.F.). Fintech might reshape this market in the future. Distributed ledger technology could enhance the effectiveness of back-end processes (i.e. speed, transparency and tracking of payments). Some banks have introduced blockchain-based payment networks for cross-border payments, partly in response to growing competition from fintech startups in the money transfer space.<sup>53</sup> If combined with digital identity technology, distributed ledger technology might have the potential to reduce regulatory compliance costs.<sup>54</sup> Alternatively, technologies that enable direct settlement of payments would allow the bypassing of correspondent banking networks altogether.

In the longer term, more widespread adoption of fintech might also impact overall financial stability (see chapter III.F.). Greater competition could threaten traditional providers' profitability and may spur excessive risk taking. Possible growth in reliance on third-party

data providers, which tend to be highly concentrated, could lead to widespread disruptions across the financial system in case of cyber incidents.<sup>55</sup> In the long term, crypto-assets could lead to more decentralized financial systems with more limited roles for traditional banks in lending and payment services. Such partial disintermediation would also affect the traditional monetary policy transmission mechanisms and could limit the role of central banks as a lender of last resort.<sup>56</sup> At present, the size of fintech providers, and the limited role of crypto-assets in the financial system are too small to pose a significant stability risk to the sector, but careful monitoring is warranted.<sup>57</sup>

Three main policy lessons emerge from this analysis. First, regulatory approaches need to balance opportunities and risks. Neither one should be elevated over the other; an environment that advances innovation, financial inclusion and market efficiency must be maintained, while risks to consumers and the financial system as a whole remain a priority consideration. Regulatory sandboxes are one tool to create controlled environments where new technologies and innovations can be tested, without immediately endangering other policy objec-

tives. Dialogue between policymakers and regulators and new service providers can facilitate a better understanding of different perspectives and needs and serve to level the playing field between traditional and new actors. Second, regulation needs to shift its focus from regulating specific entities toward regulating activities. As new service providers enter the financial system, they need to be brought within the perimeter of regulatory systems as well; this is beginning to be the case with crypto-asset services providers. Third, as fintech is rapidly evolving, regulatory approaches should strive to be technology neutral and capable to respond in real-time, or close to it. This will require spaces for peer learning among countries and enhanced capacity-building support by the international community.

#### 4.4 Fintech and inequality

By expanding financial breadth and expanding access to financial services, fintech has the potential to help reduce inequality, including on the basis of gender, while also stimulating economic growth. Yet, ever more granular machine learning allows financiers to discriminate more accurately. They can thus better price risk and rely less on pooling of risk, but this could in turn contribute to inequality. Individuals may be priced out due to data analysis and the predictability of certain events (e.g., crop insurance might not be offered to farmers where data accurately predicts poor weather; health insurance might not be offered to individuals whose data suggest they are higher risk). This increasing ability to target clients poses new policy challenges in trying to best reconcile equity and efficiency considerations.

## 5. Access to technologies and innovative solutions

Ideas, knowledge and technology have become more important for sustainable development and economic growth in an economy increasingly characterized by intangibles. The discussion on fintech above has shown both their potential to contribute to development priorities, but also highlights the continued divides in access and use. This section explores how to address this divide, and how to improve developing countries' access to technology and innovation for sustainable development and outlines the main channels for international technology transfer.

### 5.1 From technology access to innovation<sup>58</sup>

Technological learning and innovation depend on the ability of countries to access, adapt and diffuse technological knowledge. Technology transfer, whether on a commercial or non-commercial (concessionary) basis, occurs when there are economic incentives to commercialize a given technology in a new location through,

for example, trading products, licensing or investing. It is often a collaborative and complex process, partly because technology has an important tacit component; knowledge that is not codifiable and is acquired through learning by doing.

There are many conduits of technology transfer, including trade; licencing; foreign direct investment; movement of workers, managers, professionals and academics; inter-university technology collaborations,<sup>59</sup> and open sources of knowledge (Table 2). Their effectiveness for technology transfer depends on: (a) economic incentives related to geography, market size, and competitiveness; (b) absorptive capacities, including human capacities, skills, governance, and infrastructure; and (c) policy and legal frameworks in the areas of, for example, trade, taxation, migration and intellectual property rights.

**Intellectual Property Rights:** Intellectual property rights (IPRs) are important factors in all the technology transfer channels outlined in table 2. In particular, published patent applications and patents are an important source of technological information, which is classified in accordance with detailed technical features and with a fairly uniform structure all over the world. Beyond this role in disseminating information, whether and to which extent IPRs promote or prevent technology development, access, transfer, and adoption is an empirical question that varies over time and depends on the specific country, sector and technology context, as well as the context in trading partners, in each case. Commercialization or licensing of technologies by foreign investors may hinge on whether IPRs are effectively protected; but certain kinds of IPR regimes may render other means of technology acquisition more costly, such as applying knowledge revealed in patents, imitation and reverse-engineering.<sup>60</sup> In general, the number of patents granted in developing countries and LDCs are much smaller than those in developed countries.<sup>61</sup>

Patents tend to play a greater role in appropriation of technology when knowledge is easily codified, such as in pharmaceuticals. They have less relevance in areas where knowledge is more tacit, or when other factors (e.g., learning curves, organizational capabilities, marketing) guarantee appropriability of returns.<sup>62</sup> What works and which level of IPR protection is most conducive to sustainable development in a given country also depends on the prevailing actions by private and public actors who file, manage and enforce their IPRs in that country. In countries where the majority of patent applications are filed by foreign applicants, their behaviours may be also relevant. The rise of strategic patenting has led to a complex system of patents which may support the rights of incumbent firms over new, smaller, innovative firms in developed and developing countries. Against this background, some patent offices have been exploring ways to improve patent quality over quantity.<sup>63</sup>

**Absorptive capacities:** The success of technology transfer depends on absorptive capacities at the level of firms and on enabling innovation ecosystems in which firms operate. If the innovation system provides incentives to adopt technology, firms are more likely to

develop absorptive capacity. Hard and soft infrastructures, including research infrastructures and education systems, play an important role in absorptive capacities.

**Economic incentives:** The effectiveness of technology transfer depends on the discovery of economically relevant knowledge that can make the transfer commercially viable. Economic experimentation, internal trials and market tests are needed to identify what can be produced competitively, thus translating technology into innovation. Economic viability is also linked to other required productive capacities, such as backward and forward linkages, infrastructure and regulations, which may be missing in the economy. In addition, informational and financing problems usually impede technology transfer and innovation. Matching the supply of technology and knowledge with its demand is a considerable task for public agencies responsible for development and technology transfers. Once a technology has been identified, financing must be found to cover costs of adjustment and reconfiguration for its new natural, technological and economic environment, and operational costs.

## 5.2 International action for improving access to technology for sustainable development

Technology and knowledge transfer needs vary greatly by country and depend on the structure of the economy

and the level of industrialization, the overall level of development, and specific sector characteristics. There are many areas in which international action can facilitate technology transfer and support innovation to achieve the SDGs in developing countries. International support to enhance innovative solutions would include those that: (i) facilitate technology transfer through usual channels; (ii) support building domestic innovation capabilities required to adapt, use and master these technologies and to translate them into innovation; and (iii) support translating technology transfer into local innovation that is economically relevant. To illustrate some of these options, this section looks at international arrangements in the areas of health, agriculture, and climate change.

### 5.2.1 Health, medicine and pharmaceuticals

Expensive medicines/drugs can be a major factor for perpetuating poverty. For example, in 2004-05 in India, 47 million people were pushed into poverty due to health spending, mainly on medicines.<sup>64</sup> The conditions under which technology transfer strengthens local production, and results in greater access to medicines are however highly complex. They require substantive capacities in governance and public health, intellectual property and STI policy.<sup>65</sup> Increased domestic production of critical

Table 2  
Typical channels of technology transfer

Channels	Comment
Exports or imports of final goods (trade)	Technology embodied in traded capital goods is transferred through learning by using, imitating or reverse engineering. The tacit component of knowledge is not easily transferred.
Licenses	Licensing is linked to the overall technological sophistication of the economy and tends to be more prevalent in developed and some emerging economies. Technology licenses often cover use of IPRs and know-how.
Purchase of foreign firm (mergers and acquisitions)	Technology is acquired through a merger.
Strategic alliance or joint venture	Partial or solely owned.
Migration of people for work or education	Human capital is a fundamental determinant of a country's absorptive capacity. Movement of skilled labour and sending students abroad has been a key source of technology acquisition, which, however, can become limited by "brain drain".
Open sources of knowledge	Exhibitions, fairs, books, patent documents, and more recently the Internet are important open sources of information about new technologies.
Contract with research entity	Intellectual property is negotiated with foreign university lab, research institute, firm, etc.
Collaborative research, development and demonstration	Intellectual property is negotiated with foreign university lab, research institute, firm, etc.
Inter-university collaborations on technology transfer	Universities can acquire skills, technologies, and knowledge of their international partner universities, which may lead to joint publications and patenting.
Bilateral or multi-lateral technology agreement	Entities agree to share research, development and demonstration efforts and outcomes.

Sources: Gallagher 2013, Lanjouw and Mody 1996, Mowrey and Oxley 1997, Gallagher 2006, Barton 2007, Lewis 2007, Odigiri et al. 2010, Lema and Lema 2010, UNCTAD (2007).<sup>a</sup>

medicines, such as for HIV/AIDS or major communicable diseases, may also not significantly reduce the prices for patented medicines. Any incentives for local production should aim at supporting shared goals of industrial policies and health policies, for example, by strengthening an effective national regulatory authority.<sup>66</sup>

Innovative institutional arrangements and risk sharing could help reduce costs for selected medicines, provide support for the acquisition and sharing of intellectual property of certain medicines, and provide risk guarantees, equity/debt instruments and venture capital. One example in this regard is the Pool for Open Innovation against Neglected Tropical Diseases established in 2009.<sup>67</sup>

More systematic international cooperation in research, development and demonstration on medicines—including with developing countries and private sector entities—is also important. Some examples are the public-private partnership model applied to vaccines and drugs for neglected tropical diseases, and product development partnerships between academia, the private and the public sectors, such as the Drugs for Neglected Disease Initiative (DNDi).<sup>68</sup>

Compulsory licensing under the flexibilities in the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) have been used to allow generic pharmaceutical producers to use patented technology for the production of cheaper, generic versions of pharmaceuticals.<sup>69</sup> Against this background, some have argued to broaden the discussion of the use “measures necessary to protect public health and nutrition” under TRIPS<sup>70</sup> to consider affordable solutions for malnutrition<sup>71</sup> and access to medical equipment, such as diagnostic, therapeutic, and surgical devices.<sup>72</sup> However, some have argued that since the transfer of know-how not disclosed in a patent application can only be made by concluding voluntary licenses or through reverse engineering, the effectiveness of compulsory licenses in technology transfer is limited to the cases where the technology is already known and only access to it is required.<sup>73</sup> LDCs can take advantage of transitional provisions in the TRIPS Agreement that exempted them from applying all substantive TRIPS standards until 2021, for example, to push the development of their manufacturing capacities. In addition, LDCs benefit from an extended transitional period, until January 1, 2033, with regard to pharmaceutical patents and test data protection for pharmaceutical products (including enforcement procedures and remedies).

Regional trade can create larger, regional markets, through a mutual recognition of certifications and approvals with trading countries. International cooperation can play a role in providing technical training and capacity building in certification and approval and for participation in international standard-setting bodies in the pharmaceutical sector. On the other hand, free trade agreements that extend patent terms beyond 20 years, which is not required by the TRIPS Agreement restrict production of generics, could severely impact access to health care.<sup>74</sup>

## 5.2.2 Agriculture

Technology access in agriculture to ensure food security is of existential importance. It depends on integrating knowledge flows, science, technology and indigenous capabilities into an effective agricultural innovation system. Many developing countries have relied on international agricultural research, but knowledge spillovers tend to be ecozone-specific, which means the research gaps have contributed to perpetuating productivity gaps between countries.<sup>75</sup>

In the past, the Consultative Group on International Agricultural Research (CGIAR) has promoted international cooperation in agricultural research, development and demonstration. It has systematically generated innovations that have become available worldwide, such as the “green revolution”. The CGIAR continues to coordinate global research partnerships on food security, such as the New Rice for Africa, and the Next Generation Cassava Breeding initiatives. The participation of research centres from developing countries in CGIAR partnerships has generated local knowledge and agricultural technology transfer on a large scale.

However, local research to resolve local problems and develop local varieties remains a bottleneck. Biotechnology could be more widely used to insert new crop traits amenable to local conditions, provided regulations and IPR constraints can be overcome. Some experts have pointed to parallels between the patents and access to medicines and the transfer of climate change technologies to poor countries and have suggested the use of the TRIPS flexibilities, including compulsory licensing, to enhance agricultural technology transfer to developing countries.<sup>76</sup> International and South-South cooperation is important, and triangular cooperation, wherein a developed country sponsors South-South technology sharing efforts, has also shown promise as a model for agricultural technology transfer.<sup>77</sup>

## 5.2.3 Climate change

Technology transfer has been a key element of the United Nations Framework Convention on Climate Change (UNFCCC). The Clean Development Mechanism (CDM) was developed as the central instrument for transferring green technologies from developed to developing countries. It was promoted in 1997 at the third UNFCCC conference and was significant from a technology-transfer perspective as it involved allowing developed countries to count emissions reduction from CDM investments in developing countries towards meeting their legally binding obligations. Reductions would count only for projects that would not be commercially viable under normal circumstances. The assumption was that CDM projects would bring with them new technologies or innovative applications and the accompanying know-how.

Estimates suggest that only one-tenth to one-third of the CDM projects have enabled technology transfer.<sup>78</sup> South-South transfers represented only 10 per cent of

the total. High-tech and energy projects, such as wind turbines or solar panels, generated more transfers, while traditional sectors such as agriculture or construction materials created less. Some of the factors that could affect the extent of technology transfer involved in CDM projects include tariffs on imported equipment and recipient countries' capabilities to absorb technology.<sup>79</sup>

The bulk of the environmentally sound technologies have been developed in response to explicit and strong government support, in the form of tax incentives, research and development (R&D) grants, favourable regulatory frameworks, and government expenditure policies. The large public stake in these technologies could provide Governments with leverage to disseminate them more broadly in the larger public interest. Yet, these policies were generally aimed at enhancing national competitiveness, which may run counter to the goal of facilitating technology transfer to developing countries.<sup>80</sup>

IPR constraints and risk-sharing arrangements have been high on the agenda in climate technology debates. Institutions have been created with the aim to supporting risk reduction and risk sharing. They provide support for the acquisition and sharing of intellectual property, risk guarantees, equity/debt instruments and venture capital. Promising developments in this regard at the global level include the Green Climate Fund private sector facility; the Eco-Patent Commons of the World Business Council for Sustainable Development; and WIPO Green—Marketplace for Sustainable Technology. However, a cautionary note is due on IPR issues. A United Nations Environment Programme (UNEP) survey<sup>81, 82</sup> found that the willingness to out-license clean technology to developing countries has been much higher than the actual, relatively low level of licensing. Seventy per cent of survey participants said they were prepared to offer more flexible terms when licensing to developing countries with limited financial capacity. Instead,

respondents considered scientific infrastructure, human capital, favourable market conditions, and investment climate as more important than protection of IPRs in the country of the licensee (in the case of developing countries). Most respondents favoured collaborative research and development activities, patent out-licensing and joint ventures over patent pooling and cross-licensing.

Many business incubators and accelerators for climate technology have been founded around the world. They support business plans and product development, build capacity for production skills and provide seed money. Interesting models in this regard are the Centre for Innovation, Entrepreneurship and Technology in Brazil and the Centre for Innovation, Incubation and Entrepreneurship in India. At the global level, the World Bank has run climate innovation centres for several years.

The UNFCCC Climate Technology Centre and Network is a technology mechanism to promote investment and technology transfer, by promoting partnerships among existing global and regional centres, online technology information platforms, clearing houses, technology instruments of international agreements, relevant economic partnership agreements, international financial institutions and technology funds. It links many similar national and international efforts. Further support will be needed to accelerate progress.

#### 5.2.4 Common institutional components to facilitate technology access in health care, agriculture and climate

There are four types of common institutional components that have proven useful for facilitating technology access in health, agriculture and climate (table 3). They could be strengthened in the form of international networks of national and local institutions.

**Table 3**  
**Institutional components of technology access in health care, agriculture and climate**

Type	Function	Institutional models
Research cooperation	Strengthen global cooperation in research, development and demonstration, and the participation of developing countries	CGIAR; public-private partnership model applied to vaccines and drugs for neglected tropical diseases.
Incubators	Support business plans and product development, build capacity for production skills and provide seed money	World Bank climate innovation centres; Centre for Innovation, Entrepreneurship and Technology (Brazil); Centre for Innovation, Incubation and Entrepreneurship (India)
IPRs and risk sharing	Reduce and share risk would aim to provide support for the acquisition and sharing of intellectual property, risk guarantees, equity/ debt instruments and venture capital; build links with public-private and philanthropic partnerships on collaborative intellectual property systems and licensing, organizations providing risk capital and a global venture capital fund	Green Climate Fund private sector facility, the South-South Global Assets and Technology Exchange System, the Pool for open innovation against neglected tropical diseases, the Eco-Patent Commons of the World Business Council for Sustainable Development, and WIPO Green—Marketplace for Sustainable Technology
Technology transfer and information	Promote investment and technology transfer, by promoting partnerships among existing global and regional centres, online technology information platforms, clearing houses, technology instruments of international agreements, relevant economic partnership agreements, international financial institutions and technology funds	UNFCCC Climate Technology Centre and Network; Technology transfer facilitation mechanism of the Asian and Pacific Centre for Transfer of Technology; Technology Bank for the LDCs, UNIDO technology centres; green revolution model of publicly funded centres

### 5.3 Technology transfer in an increasingly digitalized global economy

The increasing digitalization and connectivity in the production of goods and services will impact the process of technology transfer. Experience with the digital industry underlines the potential for increasing access to technology, as well as challenges in managing intellectual property. New and emerging technologies that combine algorithms and data with the physical and biological sphere could open new opportunities for technology transfer but also unforeseen challenges.

Traditionally, the digital industry has been a sector particularly amenable to technology transfer given that its products exist as pure applied and codified knowledge. In this context, free and open-source software (FOSS) has explicit copyright and end-user licenses that permit users to copy and redistribute software without restrictions. This makes FOSS particularly easy to transfer and absorb. It requires that authors of a programme make its source code publicly available and permits “looking under the hood,” thereby supporting human capacity development in ICT and computer science. This is a particularly important issue given the challenge of improving absorptive capacity and therefore the likelihood of a successful technology transfer in many developing countries. FOSS generates positive economic externalities, including improvements in technology transfer flows and development of absorptive capacities.<sup>83</sup>

International cooperation has also produced numerous examples of technological transfer based on software products. For example, United Nations Conference on Trade and Development (UNCTAD) developed the Automated System for Customs Data (ASYCUDA), a computerized customs management system whose implementation strategy aims to ensure the full transfer of know-how on custom automation to ensure national long-term sustainability (see box 3).

Digital technologies can lead to economically viable innovations in developing countries when they offer an alternative to costly infrastructure investments needed for traditional technological paradigms. For example, rapid technological advances and associated cost reductions in ICT in recent decades have enabled some developing countries, notably in Africa and Asia, to skip the development of analogue landline infrastructure by moving directly to digital mobile telecommunications. Several countries that had low levels of penetration of fixed and mobile telephones in the early 2000s had reached levels of subscriptions of mobile-cellular telephones per 100 inhabitants above the global average (108.9) by 2017. Such is the case of the Gambia (139.2), Côte d’Ivoire (130.7), Ghana (127.5), Nepal (123.2), Timor-Leste (119.3), Cambodia (116) and Mali (112.4).<sup>84</sup> Leapfrogging contributed to increased productivity and the creation of new markets, such as in fintech services (see section 4).

At the same time, a digitalized economy implies new considerations for technology transfer. For example, since these new and emerging technologies rely on

#### Box 3

#### ASYCUDA: Technology transfer for custom automation

UNCTAD’s ASYCUDA programme provides technology transfer for custom automation, custom reform and streamlining of the customs clearance process, with a view to promote trade facilitation. Over a period of more than 36 years, it has supported customs administrations of 115 countries and territories. Having originated to help countries build and utilize the data collected at customs ports of entry through databases, the programme’s scope has gradually widened to helping countries manage their economic and financial analysis and planning, as well as assisting the private sector in doing business. It has also expanded the customs management functions it supports, from the initial data capture (now uploaded via the Internet) to assisting countries and territories in monitoring trade crossing, trade statistics, and producing data critical to risk management analysis, among other issues.

Source: UNCTAD.

digital data, the control of data and the rules to facilitate or hinder their transfer are critical for technology transfer. In the case of AI and machine learning, algorithms may be less important than access to data used to develop, train and execute those algorithms. Digital assets are also scalable at very low costs, which has led to highly productive and profitable industry leaders and increased market concentration. Growing productivity gaps between firms suggest that technology diffusion has decelerated within industries, which could also affect cross-border diffusion of technologies. How these relations will play out is uncertain, but enormously consequential in an increasingly digital age, and thus calls for a better understanding of digital technology diffusion and transfer.

## 6. Development cooperation and United Nations actions on science, technology and innovation

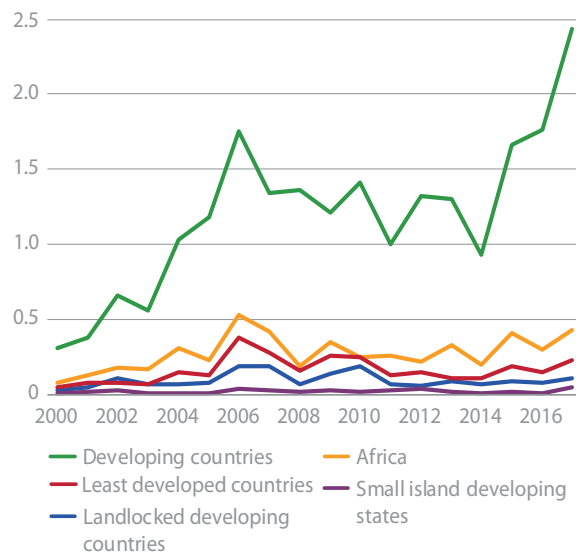
### 6.1 Development cooperation for Science, technology and innovation

Official development assistance (ODA) targeting the development of STI capacities in developing countries has increased in the past two decades and more than doubled since 2014, from almost \$0.9 billion to \$2.4 billion

in 2017. However, ODA for STI capacities directed to the LDCs, land-locked developing countries and small island developing States, as well as for developing countries in Africa, has remained at the about same levels for the past decade.

At the same time, international collaboration in scientific research, including both North-South and South-South collaboration, has grown considerably in recent decades, opening new opportunities to address pressing issues in key areas of sustainable development. The North-South divide in research and innovation, while still large for many countries, is narrowing overall, as more countries incorporate STI in their national development strategies.<sup>85</sup> Increased R&D spending and institutional strengthening over the past 20 years have encouraged more cross-border collaborations. International collaborations are also driven by coordination of research towards specific questions (due to lower communication costs), and by open access to data and publications.<sup>86</sup>

**Figure 3**  
**Official development assistance for scientific, technological and innovative capacity by recipient, 2000-2017**  
(Billions of United States dollars)



Source: OECD Creditor Reporting System and UN/DESA calculations

Notes: Includes ODA commitments reported under education, medical, energy, agricultural, forestry, fishery, technological and environmental research, ICT and research and scientific institutions.

The capacities of many developing countries to participate in international collaboration have increased considerably. In 2014, 86 per cent of scientific publication in low-income countries had international co-authors (from 80 per cent in 2008), with 38 per cent in lower-middle income countries (from 29 per cent in 2008). Countries who are in the phase of building up their research capacities often begin by establishing projects with teams in scientifically advanced countries (both in the global North and South). As their research

capacity increases, countries move on to the phases of consolidation and expansion, followed by internationalization, where they can take the lead in international projects. China, Singapore and Thailand, for example, now serve as scientific hubs for neighbouring countries in their region.<sup>87</sup>

Regional and international collaboration has also increased in scientific research and capacity-building for frontier technologies. Programmes such as the European Union's Marie Curie grants have helped promote collaboration and mobility and created regional and international scientific networks of researchers.<sup>88</sup> The online education platform Fast.ai offers free classes on deep learning with the aim of increasing diversity in AI. The platform has launched diversity and international fellowships for deep learning, providing an opportunity for participants to receive state of the art practical education in AI.<sup>89</sup>

## 6.2 Actions by the United Nations system and others

Several United Nations agencies have ongoing programmes for enhancing the capacity of the Member States of the United Nations on STI. UNCTAD conducts science, technology and innovation policy reviews upon request of countries to support the development of their national capacities in STI policy formulation and implementation. The STI policy review framework is being revised to strengthen the focuses on STI for the SDGs. UNCTAD also conducts eTrade Readiness Assessments to assist developing and least developed countries in assessing their readiness to engage in and benefit from e-commerce, and it develops national strategies and provides policy advice to countries in building and maintaining a dynamic and responsive ICT policy environment for trade and development. The United Nations Economic Commission for Europe (UNECE) carries out reviews of innovation policies in countries with economies in transition, for which the question of the absorption is particularly relevant.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) launched the GO-SPIN Platform<sup>90</sup> in November 2018 with information on STI policies, policy instruments, and legislation related to 55 countries. UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Italy has been working with centres of excellence in Africa.<sup>91</sup> The ICTP is also training scientists from developing countries in the field of quantum technologies. UNESCO's environmental programmes are integrating the IoT and AI. For example, UNESCO G-WADI Geoserver application (Water and Development Information for Arid Lands—a Global Network) uses an artificial neural network algorithm to estimate real-time precipitation worldwide, and it is now available through the iRain mobile application to facilitate people's involvement in collecting local data for global precipitation monitoring.<sup>92</sup>



UNESCO is also now “Harnessing AI to Achieve SDG 4” to ensure that the Member States are ready to leverage AI to ensure inclusive, equitable quality education and lifelong learning opportunities for all and to mitigate AI’s possible negative impacts. UNESCO is also working with Ericsson on “Artificial Intelligence for Youth” to help youth develop AI-related digital skills, and with Airbus on an international competition that encourages science and engineering students to develop sustainable solutions to global problems. Its STEM and gender advancement tools improve measurement and policies for gender equality in STEM fields. The Digital Skills for Jobs Campaign, led by the International Telecommunications Union (ITU) and international Labour Organization (ILO), mobilizes partners to invest in digital skills training opportunities for young women and men so that they can benefit from the opportunities offered by the digital economy, and to help countries make economic growth more inclusive.

WIPO assists Member States in the development, formulation and implementation of national IP and innovation strategies, including by enabling them to use the Global Innovation Index to set innovation policy targets. In addition, WIPO. It has developed WIPO GREEN,<sup>93</sup> a global marketplace that promotes green tech innovation and diffusion. WIPO has also developed an IP Toolkit for academic and research institutions to help them shape and implement their institutional intellectual property policies.<sup>94</sup> The International Atomic Energy Agency (IAEA), through the implementation of national, regional and inter-regional programmes and projects in four geographic regions, helps countries to address key development priorities and assists in the establishment of national legal frameworks for the safe, secure and peaceful uses of nuclear energy and ionizing radiation.

The United Nations Department of Economic and Social Affairs (UN/DESA) is implementing a four-year project for mobilizing STI in developing countries for the SDGs. The ITU has a large capacity-building programme focusing on strengthening skills among its membership in a wide range of ICT-related topics. Through the ITU Academy, which has more than 10,000 users, and its Centres of Excellence network, it delivers in-person and e-learning courses. The annual AI for Good Global Summit also provides an important opportunity for global and inclusive dialogue on AI.

### 6.3 Technology Facilitation Mechanism

The Third Annual Multi-stakeholder Forum on Science, Technology and Innovation, which was held under the umbrella of the Technology Facilitation Mechanism (TFM) in New York in June 2018, was attended by more than 1,000 participants, representing Governments, scientists, innovators, technology specialists, entrepreneurs and civil society. The Forum explored policies and actions for advancing STI to achieve the SDGs. It proposed a list of recommendations that addressed, inter alia, STI roadmaps and disruptive societal im-

pacts of new technologies, such as nanotechnology, automation, robotics, AI, gene editing, big data, and 3D printing.

The membership of the Interagency Task Team on Science, Technology and Innovation for the SDGs (IATT) now comprises more than 100 staff experts from 41 United Nations entities. In cooperation with the 10-Member Group of high-level representatives, it has undertaken joint activities in seven subgroups on the STI Forum; the TFM online platform; STI roadmaps for the SDGs; joint capacity building; new and emerging technologies; and gender and STI.

In 2018, the IATT developed a demo version of the TFM Online Platform<sup>95</sup> as a gateway for information on STI initiatives, mechanisms and programmes around the world, and to connect suppliers and users of technologies for the SDGs.<sup>96</sup> IATT members have also pooled training resources on STI policies and started jointly delivering capacity building workshops with participation from seven United Nations entities, including in Jordan and Panama. Partnerships are also emerging with scientific and technological communities and other stakeholders.

As an activity towards fulfilling the follow-up to General Assembly resolution A/RES/72/242, the IATT organized the second “Expert Group Meeting on Rapid Technological Change, Artificial Intelligence, Automation, and Their Policy Implications for Sustainable Development Targets” in Mexico City in April 2018. The IATT has continued this work and has collected inputs from over 100 contributors (box 4).

## 6.4 The work of the Commission on Science and Technology for Development

As the United Nations focal point for STI, the Commission on Science and Technology for Development (CSTD) acts as a forum for strategic planning and sharing lessons learned and best practices. It provides analysis and foresight about critical trends in STI in key sectors of the economy, the environment and society, drawing attention to emerging and disruptive technologies. The twenty-first annual session of the CSTD was held from 14 to 18 May 2018 in Geneva and addressed two priority themes: (i) the role of science, technology and innovation in increasing the share of renewable energy by 2030; and (ii) building digital competencies to benefit from existing and emerging technologies, with special focus on gender and youth dimensions.

In 2018 the CSTD worked with the Chinese Government to strengthen South-South collaboration in the area of STI and to develop a set of customized training courses on STI capacity-building. The collaboration will continue in 2019 with a young scientist program through which 24 scientists from CSTD developing countries will have the opportunity to work in China from six to twelve months and exchange experience and knowledge.

CSTD has also made efforts to strengthen the collaboration between CSTD and United Nations regional commissions and other stakeholders, including in Asia and Africa.

## 6.5 The Technology Bank for the Least Developed Countries

The General Assembly established the Technology Bank for the Least Developed Countries at the end of 2016. Its operational activities started in 2018, focusing on preparing science, technology and innovation/technology needs assessment reviews and on digital access to

research. The needs assessment reviews aim at identifying technological gaps and priority needs and providing recommendations for strengthening policies and measures to improve national and regional technological capabilities and encourage innovation. The Technology Bank entered into arrangements with UNESCO for the preparation of the reviews of Guinea, Haiti, Sudan and Timor Leste and UNCTAD for the preparation of the review of Uganda.

Under its work on digital access to research, the Technology Bank, together with the UN partnership Research for Life, aims to facilitate online access to scientific journals, books, and databases at no direct charge to LDC beneficiaries. 38 workshops were held in 2018 in 10 LDCs.

### Box 4

#### Initial TFM findings on the impact of rapid technology change on the SDGs

At the Third Annual Multi-stakeholder Forum on Science, Technology and Innovation, held in New York in June 2018, the initial findings by the Technology Facilitation Mechanism (TFM) on the impact of rapid technology change on the achievement of the SDGs<sup>97</sup> were presented. These findings were based on inputs by the TFM's Interagency Task Team, the 10-Member Group of high-level representatives, eight meetings<sup>98</sup> and sessions on the topic under the TFM umbrella<sup>99</sup>, and inputs by UNCTAD, DESA, UNU, ECLAC, ESCAP, ESCWA, ITU, ILO, WIPO, World Bank, the International Science Council and the Major Group on Children and Youth. The Interagency Task Team on Science, Technology and Innovation for the Sustainable Development Goals (IATT) subgroup on new and emerging technologies continues to collect and synthesize inputs for an updated presentation at the Fourth STI Forum in 2019. The work of the IATT on the potential and risks of technology, development and employment impacts, and on education have informed this chapter. Additional findings include the following:

- **Natural environment:** New materials, digital, bio-, and nanotechnologies, and AI all hold great promise for a range of high- efficiency water and renewable energy systems that could be deployed in all countries and catalyse the global move towards sustainability. However, despite efficiency increases, AI and all the other emerging technologies clusters will require an ever-increasing use of electricity, creating more pollution and waste (e.g., e-waste, nano-waste, and chemical wastes). Such outcomes demand that environmental considerations be incorporated into the design of these technology systems from their inception.
- **Norms and ethics:** A more responsible and ethical deployment of new technologies have to be balanced against concerns that excessive restraints on innovations may deprive humanity of many benefits. Ethical and normative considerations that should guide our thinking on these issues have to spring from our shared vision—the values contained in the United Nations Charter, the Universal Declaration of Human Rights, the Rio+20 outcome “The Future We Want”, and most recently the 2030 Agenda for Sustainable Development.
- **Multi-sectoral and multi-stakeholder engagement:** Fostering policy coherence and multi-stakeholder dialogue is more important than ever. This requires coherence across policies for the macro-economy, science and technology, industrial development, human development and sustainability. Multi-stakeholder dialogue is essential in order to include different perspectives, to arrive at shared understanding and to establish trust.

## Endnotes

- 1 This section is based on United Nations Conference on Trade and Development, *Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development* (New York and Geneva, 2018).
- 2 See, for example, Robert W. Fogel, “Catching up with the Economy”, *American Economic Review*, vol. 89, Issue 1 (March 1999), p. 1-21; Sebastian Anthony, “Transistors will stop shrinking in 2021, but Moore’s law will live on”, *ARS Technica*, 25 July 2017; Tom Simonite, “Moore’s Law is Dead. Now What?”, *MIT Technology Review*, 13 May 2016.
- 3 United Nations, document E/CN.16/2015/3.
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