UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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HARNESSING RAPID TECHNOLOGICAL CHANGE FOR INCLUSIVE AND SUSTAINABLE DEVELOPMENT

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NOTE

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This series of publications seeks to contribute to exploring current issues in science, technology and innovation, with particular emphasis on their impact on developing countries.

The designations of country groups are intended solely for statistical or analytical convenience and do not necessarily express a judgment about the stage of development reached by a particular country or area.

The term “dollars” ($) refers to United States dollars unless otherwise specified.

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ABBREVIATIONS

e-commerce	electronic commerce
ICT	information and communications technology
ODA	official development assistance
STEM	science, technology, engineering and mathematics
STI	science, technology and innovation

I. INTRODUCTION

People currently live longer and healthier lives, on average, achieve more years of education and have better access to clean water, sanitation and electricity. A global middle class has emerged, fuelled by rapid growth in emerging economies. At the same time, poverty persists in some areas, with more than half of the world's extreme poor living in sub-Saharan Africa (United Nations, 2019a). Wealth is concentrated, with the richest 1 per cent in the world owning more wealth than 90 per cent of the global population (Coffey et al., 2020). Disparities in education, health and income opportunities still run deep along the lines of gender, location (urban versus rural) and country of birth. In addition, new forms of disparities are emerging in access to enhanced development outcomes such as life expectancy at an older age and tertiary education. As illustrated in *Human Development Report 2019,* a child born in the year 2000 in a country with a low level of human development is 17 times less likely to be alive today than a child born in a country with a high level of human development. The chance to have achieved higher education is also much lower; only a 3 per cent chance compared with a 55 per cent chance for children born in a country with a high level of human development (United Nations Development Programme, 2019). Global inequality between countries has recently been reduced, but remains high, and within-country income inequality has increased in most economies (Milanovic and Roemer, 2016).

Technological change is essential for economic growth and sustainable development, but it can initially widen inequalities. From a user perspective, recent technological advances could bring significant benefits that touch on all of the Sustainable Development Goals (UNCTAD, 2018a). However, not everyone has immediate access to such progress, such as life-saving treatment, clean water, specific knowledge or a piece of technology. As noted by economist and Nobel laureate Angus Deaton (2015), "inequality is often the consequence of progress". If the dissemination of new technologies is limited to already advantaged groups, this could reinforce a vicious cycle that widens existing inequalities. For example, those with higher incomes tend to be the first to adopt new technologies. Such differential access creates new opportunities in areas such as education, health and employment for those already possessing an advantage. Those with access to wealth and power can also affect the direction of innovation in ways that can increase inequality, for example, by crowding out innovation targeted at the poor.

At the same time, people are both consumers and producers. Their living standards and levels of access to new technologies depend on how they generate income. In this regard, some frontier technologies (e.g. artificial intelligence, digital platforms and robotics) can significantly disrupt labour markets. As most people earn through the supply of their labour, they will not be able to consume the benefits of most of these technologies if they are pushed or kept out of labour markets.

Therefore, to harness rapid technological change for inclusive and sustainable development, Governments and other stakeholders need to ensure that on the user side, the benefits of frontier technologies reach the greatest number of people and, in particular, the most vulnerable and those further behind. They also need to ensure that rapid technological change results in more and better jobs in developed and developing countries, that those caught on the losing side during a transition have the support to find new livelihood paths with dignity, that innovation in frontier technologies is carried out alongside healthy competition to avoid excessive market concentration and that less technologically advanced countries have the support of the international community in their aspirations to catch up with more technologically advanced economies.

This study advances the discussion and critically examines how to make frontier technologies work for all. It presents possible points of concern regarding inequalities that technological change might exacerbate, which science, technology and innovation (STI) policies need to address in future. The analysis explores ways to steer rapid technological change towards improved inclusiveness in terms of income, gender, age group, people with special needs and other groups facing specific challenges. To keep the discussion focused, the inequalities considered in this study are not necessarily linked to all frontier technologies, but mainly to a set of digital frontier technologies, including artificial intelligence, big data and robotics. This study focuses on ways to assist the development of appropriate business models that allow for inclusive innovation using frontier technologies to be scaled up for inclusive and sustainable development.

The study is structured as follows. Chapter II discusses some of the potential channels of the impact of rapid technological change on inequalities and how to mitigate this threat. Chapter III examines in more detail the role of inclusive and sustainable innovative business models in making the dissemination of frontier technologies more inclusive. Chapter IV discusses the role of STI policies in creating an environment for harnessing frontier technologies, to ensure that no one is left behind. Chapter V discusses international collaboration. Chapter VI concludes with policy considerations for member States, the Commission on Science and Technology for Development and other relevant stakeholders.

II. TECHNOLOGICAL CHANGE AND INEQUALITIES

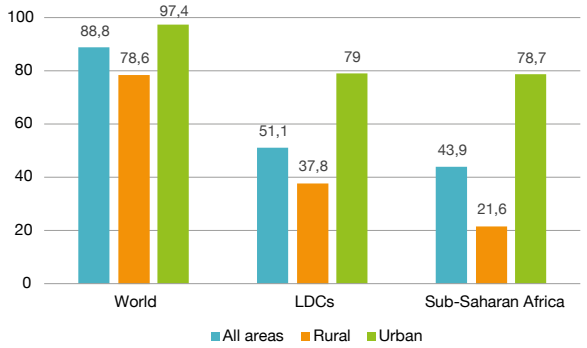
This chapter discusses some of the different channels of the impact of rapid technological change on inequalities.

A. UNEQUAL ACCESS TO NEW TECHNOLOGIES

Rapid technological change can affect inequality by leading to unequal access to products and services that are enabled by new technologies. An important issue for access to such goods and services is the availability of and access to essential technological support infrastructure (e.g. electricity and the Internet). Unequal access to such support infrastructure is closely associated with the affordability of the infrastructure and geographic disparities in its coverage (e.g. in urban versus rural and mountainous or remote regions). For example, access to electricity, despite progress at the global level, remains a luxury for a large share of the population in the least developed countries and countries in sub-Saharan Africa, particularly in rural areas. In 2017, access to electricity was available to only 37.8 per cent of the rural population in the least developed countries and 21.6 per cent of the population in rural areas in sub-Saharan Africa, compared with 78.6 per cent of the global rural population (figure 1). In this regard, frontier technologies could provide some solutions to accelerate access to electricity using renewable energy technologies and could provide an opportunity to leapfrog traditional energy technology solutions (United Nations, 2018b). For example, off-grid and mini-grid solutions using solar technology could be the most cost-effective solution to providing access to electricity to all households in sub-Saharan Africa by 2030 (UNCTAD, 2018b).

Access to digital infrastructure is critical, given that digitalization and connectivity are essential enablers of frontier technologies. Digital platforms are changing the way that people interact with each other, that businesses are conducted and that Governments relate to their citizens. In this regard, it is important to note that, in 2018, 3.9 billion people had access to the Internet, that is, for the first time, more than half of the world's population was connected to the Internet. At the same time, it also means that the other half is still disconnected and, in practice, out of direct reach of the benefits of the innovations enabled by digital platforms. The latter half of the population is not equally distributed worldwide;

Figure 1
Proportion of the population with access to electricity, urban and rural, 2017
(Percentage)



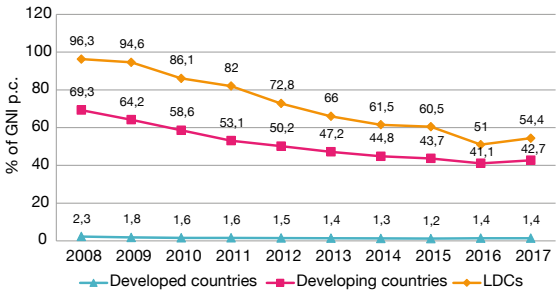
Abbreviation: LDCs, least developed countries.
Source: UNCTAD calculations, based on data from the United Nations global Sustainable Development Goals database.

less than 20 per cent of people in Europe lack access to the Internet yet over 75 per cent in sub-Saharan Africa and over 80 per cent of those in the least developed countries lack access (International Telecommunication Union, 2018).

In addition to issues related to poor digital infrastructure, affordability is also a critical element in access to new technologies. For example, the price of Internet access in developing countries and the least developed countries has been reduced by up to half since 2008, but remains high. The monthly price of fixed broadband in developed countries is, on average, 1.4 per cent of per capita gross national income, yet in developing countries, it is around 42.7 per cent and in the least developed countries, 54.4 per cent (figure 2). A similar pattern is seen in the affordability of mobile Internet; the price of the mobile cellular basket in developed countries is, on average, 1 per cent of gross national income per capita, yet in developing countries, it is 4.5 per cent and in the least developed countries, 9.8 per cent.

Access is also affected by the interplay of personal factors that enable or prevent the use of frontier technologies (e.g. basic literacy, basic digital skills, age and accessibility issues). Social factors that constrain access by certain groups of people to goods and services

Figure 2
Monthly price of a fixed broadband basket, selected groups of countries
(Percentage of gross national income per capita)



Abbreviation: LDCs, least developed countries.
Source: UNCTAD calculations, based on data from the information and communications technology (ICT) price baskets database of the International Telecommunication Union.

Box 1
Latvia: Bridging the treatment gap – Artificial intelligence in cancer diagnosis

Cancer is the second most common cause of death globally, with more than two thirds of deaths arising in low-income and middle-income countries. Overall, poorer people are less likely to undergo routine cancer screening. Furthermore, the medical treatment they receive is often of a lower quality.

Latvia has started to introduce artificial intelligence-based solutions in medicine. One pilot project financed by the Investment and Development Agency aims to use artificial intelligence technologies in cancer diagnostics for less advantaged groups. The project will focus on risk assessment, early diagnostics and forecasting techniques for lung cancer based on big data analysis. This could improve survival chances, which increase with early detection. This is a pertinent issue, as nearly 4 per cent of the population of Latvia (77,000 people) are cancer patients and there are 100 new diagnoses annually.

Sources: Contribution from the Government of Latvia, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con21_Latvia.pdf; Olaku and Taylor, 2017; World Health Organization, 2018.

can also perpetuate inequality. For example, due to social norms, girls and unmarried women in some villages in India may not be allowed to use mobile telephones (*Independent*, 2016).

This discussion shows that existing inequalities must be addressed directly and initially, prior to other specific measures, to avoid the threat of rapid technological change perpetuating or increasing inequalities. Governments and other stakeholders should continue to strive to reach universal electrification and to close digital divides. All stakeholders should also continue to address all forms of social biases and discrimination. Governments should explore ways to increase the coverage of new goods and services that use frontier technologies and achieve the Sustainable Development Goals with regard to vulnerable and low-income groups, including by providing such goods and services as public services, for example, as introduced in Latvia with regard to artificial intelligence-based solutions in medicine (box 1).

B. BIASED DESIGN

The way that technology is designed and used can also perpetuate and increase inequalities. For example, the default female voice of artificial intelligence digital assistants (e.g. of Amazon and Apple, as well as software applications used to conduct online chat conversations, or "chatbots") could perpetuate gender biases and the stereotype of women in subservient positions (United Nations Educational, Scientific and Cultural Organization, 2019). Technology built with men in mind could also reduce the benefit of products and services for women, such as in voice-recognition in cars that reacts better to lower-pitched voices and fitness trackers that underestimate activities predominantly associated with women, such as housework (Nelson et al., 2016; Tatman, 2016).

Furthermore, artificial intelligence is only as good as its training data. For example, in 2014, an artificial intelligence system developed to assist in the recruitment of software engineers was found to penalize résumés that contained the word "women". This bias was not coded in the algorithm, but the system had learned it based on the historical recruitment data of the company, which was biased. After the problem was identified, following three years of biased recruitment, a fix was introduced, but there were no guarantees that other biases would not be introduced, and the system was abandoned (*Reuters, 2018)*. In yet another case, an artificial intelligence system developed to assist judges in making better sentencing decisions based on predictions of the likelihood of criminals to re-offend was found to be biased against ethnic minorities (*Harvard Magazine, 2018*). Many other cases have been reported in which the digitalization of welfare services and the mandatory use of digital channels to access social services, work and pension, disability and health benefits, although they may improve efficiency and transparency, could also punish those that do not have digital access and skills. Glitches in such systems can also leave people

without access to benefits, which in some cases could result in life-or-death situations.[1]

The international community has a role to play in raising awareness among the private sector and other stakeholders of the unintended consequences of new goods and services that use some of these frontier technologies and that are becoming an integral part of personal, social and business interactions in many parts of the world. The companies that develop such products need to build their capacities to identify the potential negative effects of their products in society and establish mechanisms to improve their research and development processes to avoid biased designs. All stakeholders should pay particular attention to developing mechanisms to ensure that data used for training artificial intelligence applications are free from biases and discriminations that could be replicated by the applications.

C. AUTOMATION OF TASKS AND DIGITALIZATION OF ECONOMIES

Some frontier technologies (e.g. artificial intelligence and robotics) can significantly disrupt labour markets. A few highly skilled workers in creative jobs and those who own capital, data, models and algorithms stand to gain. At the same time, workers performing routine tasks are expected to face pressures from ever more capable machines and artificial intelligence software. The risk is that routine jobs may vanish as they become automated. This could increase job polarization and wage inequality, particularly in many developed countries. Some estimates of the impact of automation on jobs suggest that almost 50 per cent of jobs in the United States are at risk of automation in the coming decades as digital technologies increasingly replace people (Frey and Osborne, 2017). Others see a modest impact across occupations, of an average of below 10 per cent (Arntz et al., 2017).

Not all applications of artificial intelligence and robotics save labour and threaten jobs. If an innovation results in new products and services that fulfil previously unmet needs, it not only increases human well-being in general but also tends to create jobs. For example, chatbots and virtual assistants can provide services online and improve user experiences in dealing with Governments and businesses, services that would otherwise not be available given the significant labour requirement and/or amount of knowledge needed to provide them (box 2). At the same time, jobs are created to give support to, maintain and further develop such new services.

Box 2
Latvia and Mexico: Frontier technologies bringing public services closer

Advances in machine learning and artificial intelligence are entering the domain of the public sector. More public administrations are introducing communications tools that allow citizens to obtain more personalized answers to their queries than a website might offer, thereby making access more equal for citizens.

In Latvia, the Government is using virtual assistants to better serve citizens in e-government applications. The aim is to develop a unified virtual assistant platform for public administration. Different assistants have been introduced to date, for example, for the enterprise register, to interact with customers, and the rural support service, to verify the eligibility of recipients of aid based on their criminal records.

In Mexico, the Ministry of Foreign Affairs aims to introduce a chatbot that will streamline information in several domains, to ease outreach to Mexicans abroad with regard to general information, passport and consular services, social and financial protection abroad and civil rights such as voting.

Sources: Contributions from the Governments of Latvia and Mexico, available at https://unctad.org/meeting/commission-science-and-technology-development-twenty-third-session-virtual-informal-meeting.

Many firms that provide services through digital platforms (e.g. Airbnb, Amazon Mechanical Turk and Uber) have created an opportunity for the emergence of a gig economy. This development may reduce inequality by providing work opportunities for people that otherwise would be outside the labour force. When the services provided are tradable (e.g. computer coding and digital design, medical diagnostics, paralegal assessments and batches of work related to image recognition), anyone with access to the Internet and the right skills can join the global labour market. For example, refugees and people from vulnerable communities that have received training in digital technologies as part of the Empowerment in Action (Empact; formerly titled Tech for Food) programme of the World Food Programme have been able to find jobs as online freelancers, increasing their prospects for integration and financial self-reliance (box 3). At the same time, the gig economy could also reduce labour rights, weaken the negotiation power of workers and affect traditional occupations (e.g. taxi drivers and hospitality workers) that are in direct competition with the new products and services.

[1] See the automating poverty series in *The Guardian*, available at www.theguardian.com/technology/series/automating-poverty.

Box 3
World Food Programme: Helping refugees by teaching digital skills for joining a globalized job market

The Empact programme of the World Food Programme aims to create opportunities for refugees and vulnerable communities to find alternative livelihood paths through freelance jobs online. It is composed of tailored digital training courses that provide hard skills (e.g. data cleaning and picture tagging) and soft skills to help bridge the gap between poverty and a new career in the globalized job market. Selected participants can also learn more advanced skills, such as coding. The programme provides mentoring and coaching to help participants find work opportunities online. In 2018, together with a network of private sector companies, the World Food Programme trained more than 2,500 refugees. Over 50 per cent of trainees are women. The benefits are improved financial self-reliance, increased social cohesion and decreased dependence on humanitarian assistance. Nearly one third of graduates were able to immediately connect to online freelance work opportunities and make a monthly average income of $135. The World Food Programme is designing and deploying a model to scale up the programme, with the goal of reaching 20,000 students by end-2020 and 100,000 people over the next five years, with immediate plans to expand to East and North Africa. Pilot projects are planned in Ghana and work has begun in the Kakuma refugee camp in Kenya.

Source: Contribution from the World Food Programme.

Frontier technologies could enable improvements in machine translation, thereby helping to remove language-related barriers, and in telepresence and augmented reality applications, thereby helping to remove distance-related barriers. These developments could make high-skill services (e.g. engineering, legal, financial and medical services) globally tradable, creating many opportunities for highly-skilled workers in developing countries, but also placing such workers in developed and developing countries in direct competition (Baldwin, 2019).

New jobs will therefore also be created, in various other sectors, but it is too early to determine the net effect on labour markets, particularly when considering impacts across countries and through the channels of trade and specialization patterns. Short-term and medium-term disruptions with winners and losers are unavoidable. Governments and other stakeholders should help ensure a smoother transition period and that those who lose their jobs are able to find decent alternative livelihood paths. They should pay attention to retraining, lifelong learning and employment support mechanisms that could address the risk of technological unemployment.

D. MARKET CONCENTRATION

Frontier technologies can impact inequality through market concentration and profits. The networked nature of many platforms based on such technologies (e.g. search engines, cloud computing and artificial intelligence services) is such that winners take all, leading to market concentration. Innovative firms can earn greater profits due to temporary monopolistic situations. Such "Schumpeterian" rents, that is, greater profits that innovators earn by being the only providers of a new product or service, are an essential incentive for product innovation. Furthermore, technology products are often bundled with other products and services through which firms can further exercise their market power (Economic and Social Commission for Asia and the Pacific, 2019). In addition, process innovation using technology, such as artificial intelligence, is expected to replace workers, thereby reducing costs and potentially prices, which could increase market shares and profits. Such increases in market concentration and profits are often a direct consequence of innovation.

Although innovation creates winners and losers among firms, the positions of firms are not static. The relative positions of firms change over time, again driven by innovation. Therefore, innovation promotion can help prevent inequality due to market concentration from being perpetuated. The dissemination of innovations among firms can also promote increased efficiency through competition and the resulting incentives for process innovation. Governments and other stakeholders could support this process by creating programmes and mechanisms to disseminate the application of frontier technologies and examples of successful business models (box 4). There is also a role for competition policy, to reduce the potential negative effects of the excessive market power of leading technology firms on further innovation.

Box 4
Belgium, the Russian Federation and Turkey: Factories of the future

With rapid technological change, gaps can develop between the first adopters of technologies in the production process and those that are lagging. Several countries are introducing programmes that assist firms in learning of new production opportunities.

In Belgium, the programme "Made different: Enabling factories of the future" brings together industry clusters, industry federations and research facilities to assist with the digital transformation of industrial firms in the Wallonia region. The programme aims to raise awareness and support for such change.

Under the digital economy of the Russian Federation programme, the federal digital technologies project focuses on end-to-end digital technologies. A key focus is on supporting domestic research and development by facilitating knowledge transfer into flagship companies for the application and commercialization of new products.

Turkey established a first model factory, also called the Small and Medium-Sized Enterprise Capability Centre, in 2018, with the assistance of the United Nations Development Programme, the Ministry of Science and Technology and the Ankara Chamber of Industry. The model factory gives firms the opportunity to benefit from applied learning about new production techniques that aim to raise competitiveness and improve capabilities.

Sources: Contributions from the Governments of Belgium, the Russian Federation and Turkey.

E. WIDENING THE TECHNOLOGICAL GAP

Some frontier technologies can create opportunities for the democratization of innovation, yet may also increase the technological gap between countries. Many frontier technologies are characterized by digitalization and connectivity. Consequently, their adoption may be easier in sectors that also rely heavily on these two factors. Therefore, the technologies are usually applied first and more intensely in industries, services and segments of value chains in which more industrialized economies have a comparative advantage, widening the technological gap.

This tendency risks perpetuating technological disparities between developed and developing countries. Less technologically advanced countries diversify their economies by emulating industries that already exist in more industrialized countries. Compared with the original innovation, this is an equally difficult innovation process, in which firms must find ways to produce an existing good or service in a significantly different, and many times extremely challenging, social, economic and business environment. Given these difficulties, emulation is usually an incremental and path-dependent process (Arthur, 2010; Hidalgo et al., 2007). Therefore, they need the capacity to absorb and adapt technologies and business models to the receiving country context (Abramovitz, 1986; Lall, 1992). If the capacity gaps and technological gaps between firms in developed and developing countries are widened by the adoption of frontier technologies in the former, then emulation by firms in the latter becomes more challenging.

The technological gap between frontier firms and other firms in developed countries is also widening. This gap slows technology diffusion and enables frontier firms to capture greater market shares and profits. The technological gap therefore contributes to inequality through direct (profits) and indirect (fewer good jobs) effects.

Inequality created by frontier technologies also has a spatial dimension, in which high value-added activities tend to concentrate geographically. This result is contrary to the idea that geographical location will become irrelevant through the use of ICT. Therefore, innovation policy that has always had a geographical dimension (e.g. the creation of clusters and parks), leading to the increased concentration of innovative firms and workers with the skills they demand, may need to be reconsidered, with regard to how to address this issue to spread the benefits of innovation more evenly over a territory.

The nature of some of these technologies for economy-wide innovation could allow some developing countries to use this window of opportunity to leapfrog and accelerate their economic structural transformations.

This discussion illustrates the speculative nature of the debate on the impact of rapid technological change on inequality across countries. Existing theories and models point to possible channels of impact, but the actual effects depend on the specific sectors affected, the capacities of countries and the policies and strategies adopted. Governments and the international community should continue to promote international technological assessments and foresight exercises to better understand the impact of rapid technological change on inequality and sustainable development, including by developing models that aim to capture the effects of process and product innovations using labour-saving frontier technologies on employment and growth in developed and developing countries, as well as on inequality across countries.

III. THE ROLE OF INCLUSIVE AND SUSTAINABLE BUSINESS MODELS IN INNOVATIVE SOLUTIONS

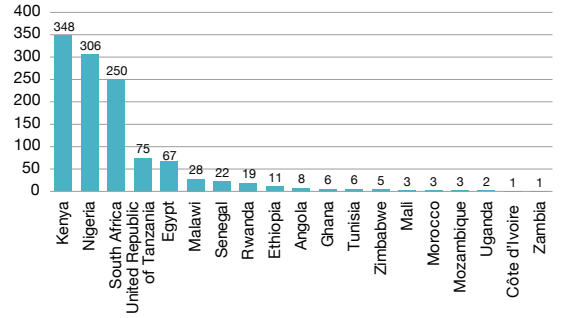
Achieving the Sustainable Development Goals by 2030 requires filling a funding gap of $2 trillion–$4 trillion annually (United Nations Association, United Kingdom of Great Britain and Northern Ireland, 2019). The public sector is essential in delivering on the Goals but cannot finance demands across all relevant sectors. Consequently, private sector contributions are important (UNCTAD, 2017). Business models that are oriented towards more inclusive and sustainable paths, both economically and environmentally, are a means to make innovations using frontier technologies economically viable and accessible to the poor while limiting possibly harmful impacts from technology. New technology diffuses in an economy through products and services, which are the result of innovation (Remane et al., 2016). Innovation, in essence, consists of the generation, transposition or adoption of business ideas, and not only technical ideas. Knowledge about a new technology does not guarantee that it will be economically viable in a new setting. Technological knowledge from the science and technology sector needs to be turned into practical applications. The business sector is one point at which this translation from theory into practice can occur (UNCTAD, 2013). Additional actors that can be involved in innovation for sustainable development are those in the research sector, organizations that support knowledge management and transfer, citizens and civil society and, evidently, the public sector (UNCTAD, 2019a).

From the perspective of consumers, inclusive and sustainable business models could also reduce the poverty premium faced by the poor, that is, the relatively higher prices for goods and services they pay compared with the prices that middle-income households might pay. This price difference can arise when there are local monopolies, weak distribution networks and strong traditional intermediaries. These factors make everyday goods such as credit, water, telephone calls and medication cost more for the poor. Demand-side factors can also play a role. For example, low-income consumers might choose products and services that have a relatively higher cost because the payment method seems to allow for more cost control (Prahalad, 2006; Prahalad and Hart, 2002). However, the poverty premium might not be as great as it once was (*Harvard Business Review, 2013)*. This is in part because of new technological developments that have made access to goods and services cheaper for everyone and also in part because consumers have become more connected and informed, and thereby more aware of the pricing and quality levels of products and services.

From the business perspective, targeting the poor makes economic sense. The global middle class has recently grown sizeably, but its purchasing power is still below that of the middle class in industrialized countries (Milanovic, 2016). In addition, a large share of the global population earns less than the average person in this new middle class. Consequently, many potential customers are either underserved or not served by certain markets. Their spending potential may not be great individually, but in aggregate they represent a large market force. As a result, a growing number of businesses now aim to combine profit and purpose. The idea of developing business models that unite making a profit and doing good by explicitly targeting low-income consumers and giving them more choices began to spread in the early 2000s (Prahalad and Hart, 2002). Today, two decades later, the idea of merging profit with purpose is no longer a matter for debate in the business community (Prahalad, 2019). Rather, it is a question of how businesses can deliver profitability while contributing to a better life for a broader number of people through their products and services.

A new wave of business ideas that are considered promising investments has emerged. According to market data from one venture fund, technological start-ups in Africa raised more than $1 billion in equity funding in 2018; total foreign direct investment to countries in Africa in 2018 amounted to $46 billion and the start-up funding consequently amounted to 2.5 per cent of overall capital inflows (UNCTAD, 2019b). This represents a growth of 108 per cent year-on-year (Partech, 2018). Nine countries received funding of more than $10 million: Kenya, Nigeria, South Africa, the United Republic of Tanzania, Egypt, Malawi, Senegal, Rwanda and Ethiopia (figure 3). Some of the recipients of the largest amounts have business models that align with the Sustainable Development Goals, particularly in the domain of financial inclusion, such as Tala in Kenya, which offers loans through a mobile application using non-traditional loan scoring.

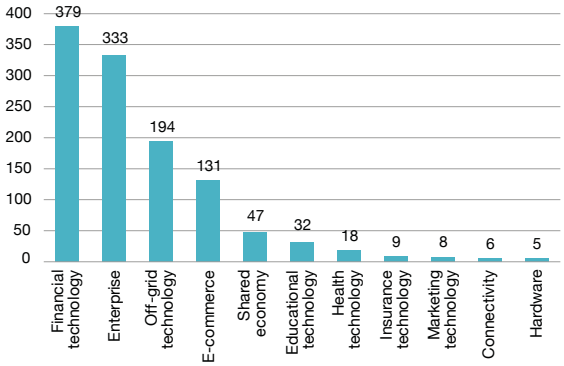
Figure 3
Equity funding to start-ups in Africa, selected countries, 2018
(Millions of dollars)



Source: Partech, 2018.

Promising solutions still need to be generated in other vital areas for inclusive and sustainable development and achieving the Goals. For example, education and health have received only a small share of all equity funding, whereas financial technology dominates (figure 4).

Figure 4
Total funding to start-ups in Africa per sector, 2018
(Millions of dollars)



Source: Partech, 2018.

Inclusive business models using frontier technologies are not restricted to those for profit, although these tend to be more sustainable economically. Delivering on inclusive and sustainable development through businesses lowers the financial burden on Governments in developing countries. In situations where continuity is a concern, viable business models with the poorest parts of society as part of their customer base are worth considering. From a resource optimization perspective, firms that make a profit could last longer than some not-for-profit initiatives. However, inclusive business models also include innovative organizational arrangements and delivery channels of public services without a profit objective (e.g. education and health) or social innovations (such as microfinance that introduces financial tools for the previously unbanked).

The following sections discuss some of the elements and characteristics of inclusive and sustainable business models for innovative solutions using frontier technologies, key issues in the development of such business models and the challenges of reaching the extreme poor.

A. ELEMENTS AND CHARACTERISTICS OF INCLUSIVE AND SUSTAINABLE BUSINESS MODELS

As in any business endeavour, supply-side and demand-side aspects matter in order for businesses to be able to contribute to inclusiveness and sustainability. Firms must find ways to deliver quality low-price products to low-income individuals since, while they may not necessarily represent a significant market individually, in aggregate they represent a large market force.

1. Supply side

On the supply side, critical elements of inclusive and sustainable business models are related to pricing, payment and overall cost. An important element is to identify the consumers of the goods and customers of the services and whether these users pay for the products or whether another party bears the costs, such as under the business model of search engines, whereby users benefit from the service while advertisers cover the monetary costs; users pay indirectly with their data, which the platforms monetize. Another element is how users engage with the business for value creation, whether in a standard way or through a more flexible approach, whereby the business customizes products to the special needs of various groups of users. The latter would be more inclusive but could be more costly and therefore less affordable. An inclusive and sustainable business model is not only about the sale of a product. The maintenance of goods and services in often challenging environments, in which technical skills, parts and related services are often unavailable, is another essential aspect to consider. Another critical factor is monetizing the new business model through the pricing system and the timing of payment collection, that is, before, during or after a service.

Inclusive business models usually rethink the entire value chain and the value proposition of products and services,

leading to new products for the low-income market. Traditional business-to-consumer business models that target richer consumers need to be comprehensively revised. Existing products cannot simply be fine-tuned and sold more cheaply. Revision requires changing the cost structure, most commonly by moving from greater margins to lower ones at a higher sales volume, to reduce the prices of inputs. Changing the cost structure in this manner is not unique to inclusive business models. However, it requires a particular effort to maximize efficiency gains and to be affordable for the poor. For example, in India, mobile telephone provider Reliance Jio achieved this, disrupting the mobile telephone market of high margins to offer low-cost telephones and cheaper mobile data (*Nikkei Asian Review, 2019*). Learnings from the new low-income market can, in turn, be used to influence the business in other market segments. Lean business models operate efficiently so that their models might be more easily transferable to low-income customers in other country contexts. Scaling up to other countries can be a necessity in some cases, if the low-income market is small in a relatively small country (Prahalad, 2006).

In reshaping business models for inclusiveness, frontier and digital technologies play an important role. Technologies can improve efficiency (e.g. telemedicine using video calls can help improve long-distance diagnostics) and contribute to new business models, for example, peer-to-peer ridesharing through applications (Baden-Fuller and Haefliger, 2013). Business models that provide application-based solutions tend to follow the business model of mobile applications and provide free services to users in exchange for the right to own and use the data generated or shared by users during transactions. Such business models can consequently create ethical issues related to the use and privacy of data (UNCTAD, 2019c). Some disruptive business models may be reactive, as they emerge as a response to technological change and the failure of previous business models to exploit new technologies for value creation. At the same time, there is a proactive element to disruptive business models that focus on customers and new ways of creating value for them (Schiavi and Behr, 2018).

2. Demand side

On the demand side, two factors are important to ensure low-income customers are drawn to a new business model: affordability and access. Low-income customers are cash-strapped and often time-poor. Inclusive business models therefore need to address these two factors.

Affordability

The total cost of ownership of a product matters. In its most basic form, this implies the purchasing cost and any required maintenance. For a good or service to make a difference, the business–customer relationship cannot end with the purchase. Long-term benefits only arise when the product keeps serving its purpose. Therefore, low-income customers often demand better price–performance ratios than other customer segments (Prahalad, 2006). The product must last longer or be more effective at a lower price. Therefore, it has to be of a better quality. For example, in conditions with irregular electricity supply, the battery charger for a mobile telephone needs to last for longer than one day. In another example, the business models of some off-grid solar-powered energy solutions include constant monitoring to address maintenance and repair. Once a unit nears the end of its life cycle, a new unit is automatically shipped to the user to prevent an interruption in service. Such models demonstrate a more holistic approach to keeping customers connected beyond their first purchase and ensuring the affordability of products, for example, as done by Fenix International and Zola Electric, two off-grid solar-powered energy solutions.

Recent business models have been taking into account the fact that the initial cost must not be prohibitive. As a result, new buying schemes are being developed that incorporate such features as lease-to-own, for example, as offered by Fenix International and Zola Electric, which have, to date, provided more than 3 million individuals with electricity in seven countries in Africa. Customers can set up the utility-in-a-box system and regularly top it up with mobile payments to use the system, buy complementary low-energy electronics or repay their loans. Once the loan payments have been fulfilled, the system unlocks permanently.

Other business models address the fact that lack of a credit score can be an important barrier to accessing credit. Some companies therefore harness customer data to create a credit score from non-traditional data. For example, Fenix International targets its product at previously unbanked customers and their repayment record is transformed into a credit score, which gives access to additional products, such as televisions, radios and satellite dishes, and also to loans for school fees and insurance. This business model is targeted toward achieving Goal 7 on affordable and clean energy, but can have additional effects in terms of employment and education outcomes. In particular, many women and girls that spend most of their time indoors benefit from the switch from fossil fuels to solar energy (UNCTAD, 2019d). Other firms aim to do

the same on a larger scale. For example, using a machine learning algorithm, Lenddo has designed propensity-to-pay scores based on the mobile telephone use patterns of customers and their social network behaviour.

Apart from lease-to-buy schemes, microfinance has expanded with mobile technology and can support affordability. For example, in Kenya, Musoni was established in 2009 as the first microfinance institution relying entirely on mobile money and, through efficiency gains by being data-driven and cashless, offers affordable loans to low-income and previously unbanked populations, of which nearly half are from rural regions and 63 per cent are women.[2] Unbanked populations are a concern not only in developing countries. In the United States, Capway plans to provide a solution for the unbanked through application-based personal finance training and bank accounts without fees. However, determining how to make a profit under this model remains an open question.

Access

Access to points of sale or delivery channels is an important demand-side factor. Business models must consider that accessing sales points is often not easy in underserved areas in developing countries, as reliable public transport might not exist and the number of privately owned vehicles is limited (Prahalad, 2006). Delivery channels are a form of providing access yet, as at 2012, 4 billion people still did not have a registered address (Universal Postal Union, 2015). Apart from the direct commercial impact of not being able to use electronic commerce (e-commerce), in many cases, this also implies a lack of legal identity, as a registered address is a prerequisite (Gelb and Diofasi Metz, 2018). However, there are new solutions to obtain, at least, a legal address. In Kenya, the M Post service allows mobile telephone numbers to be registered as addresses. The service registers a convenient post office for each account, from which mail may be picked up or delivery arranged.

In addition, inclusive business models must account for time poverty as an important access barrier. Opening hours need to match customer schedules. If customers work during the day, they cannot miss large amounts of work time to shop or run errands. Time saved is therefore critical to low-income groups. Digital technologies offer options that can ease time poverty. One tool in this regard, launched in India in 2001, is the online service Eseva, which aggregates government information and services in one place and includes e-government services such as passport application forms and utility bill payments, provided in e-centres with support staff, thereby providing a one-stop shop.[3] However, people may not be aware of some government services nor that they could be eligible for them. This awareness gap can be bridged by easing access to information through modern technologies. For example, in India, the technology platform Haqdarshak connects people with the welfare schemes for which they are eligible, based on an adaptive questionnaire. Once the questionnaire has been completed, customers can book a meeting with a trained representative of the platform to complete the application, for a fee. The platform is targeted towards impacts in achieving Goals 1, 3, 4, 5, 6 and 9. To date, approximately 220,000 people have received benefits through applications processed by the platform. Furthermore, digital platforms that provide access to expertise play an important role in business models that address sustainability and inclusiveness. Sectors that are covered are, for example, agriculture, education, employment and health (box 5).

Box 5
Digital platforms increase access to expertise

Mobile-based advisory services are increasingly supplementing agricultural solutions for smallholding farmers worldwide. In India, Kheyti is rolling out a service that bundles a modular greenhouse and high-quality inputs with mobile-based training and advice. In sub-Saharan Africa, Zenvus combines robust smart sensors with real-time analysis through cloud-based services, forming an Internet of things environment that advises on farming techniques, uses the data for insurance purposes and connects to markets. The firm Farm Better is building a mobile application for smallholding farmers in Africa and Asia that provides tailored farming advice based on a georeferenced database and a resilience survey of households and individual farming preferences that lead to specific recommendations.

With regard to education, platforms can benefit from recent advances in artificial intelligence, which allow for personalized learning and access to knowledge. Such platforms can be used privately but are also used to support public schools experiencing teacher shortages or to ensure teaching quality, such as Mind Spark Maths, Muskaan Dreams and Tai School.

Research shows that application processes are racially discriminatory (Bertrand and Mullainathan, 2004). To help achieve Goal 8 on decent work and economic growth, new digital solutions match job seekers with jobs based on their capabilities, not their credentials, for example, Shortlist in India and Kenya. Skills and strengths are assessed online to allow people to qualify even if their résumés are non-standard, and the assessment is complemented by specific advice from recruitment advisers. In addition, the digital service Bloc has

[2] See https://musoni.co.ke/company#content-vision.

[3] See https://www.indiafilings.com/learn/eseva/.

developed tools that are designed for minority students to be able to turn their experiences into marketable résumé items and to provide them with feedback on their application material (see https://www.jointhebloc.com).

Digital platforms allow access to health and medical services, even in remote, medically underserved regions. For example, two new platforms provide services that are more comprehensive than simply a call with a doctor: Mobihealth International in Nigeria offers subscription plans that connect patients with doctors, both local and abroad, and allow for referral visits and payments for medicine; and Babyl in Rwanda provides telemedicine through a call centre with medically trained staff, along with the possibility for payments, prescriptions and referrals to be handled through using short message services and for partner facilities to receive patient information from the call centre to allow for the smoother handling of cases.

Source: UNCTAD.

B. PATTERNS OF INCLUSIVE AND SUSTAINABLE BUSINESS MODELS

This study classifies 24 business models along 12 dimensions to identify the characteristics of inclusive and sustainable business models (see the table listing each firm and its characteristics in the annex). Business model patterns describe the building blocks that a firm combines to deliver on innovation and to provide value (Remane et al., 2016). Each firm has an individual pattern and the multidimensional matrix presents the overarching dimensions and the different characteristics per dimension, namely, the degree of digitalization, value proposition, value delivery, value creation and value capture. The matrix includes the count of how many of the 24 business models exhibit the selected characteristics.

Table 1
Business models: Dimensions and characteristics per dimension
(Number of models exhibiting each characteristic)

Digitalization	Degree of digitalization	Purely digital: 7	Digitally enabled: 16	Not necessarily digital: 1		
Value proposition	Product type	Physical: 13	Financial: 15	Professional advice: 16	Intellectual property: 9	Hybrid: 19
	Strategy for differentiation	Quality: 17	Customization: 11	Combination: 19	Access/convenience: 18	Price: 17	Network effects: 6
Value delivery	Target customer	Specific new customer segment: 22	Lock in existing customers: 3	Other companies (business to business): 6		
	Value delivery process	Brand and marketing: 9	Sales channel: 5	Sales model: 11	Customer relationship management: 21	
Value creation	Sourcing	Make: 20	Buy: 4	No impact on sourcing: 2		
	Third parties involved	Suppliers: 5	Customers: 7	Competitors: 0	Multiple parties: 2	No impact on third parties: 14
	Value creation process	Research and design: 16	Supply: 15	Production: 12	Multiple steps: 15	
Value capture	Revenue model	Selling: 18	Lending/leasing: 5	Intermediate: 8	Advertising: 0	
	Pricing strategy	Premium: 1	Cheap: 14	Dynamic: 4	Non-transparent: 8	
	Profit intent	For profit: 20	Not for profit: 2			
	Direct profit effect	Increase revenue: 9	Reduced cost: 6	Multiple effects: 3	No direct profit impact: 12	

Notes: N=24; characteristics may overlap and rows therefore may not add up to 24; the darker the colour of a cell, the more frequent a characteristic is across the businesses analysed.
Source: UNCTAD, based on Remane et al., 2016.

The matrix shows that two thirds of the business models analysed are digitally enabled. Typically, the businesses combine an application or a web-based platform with an additional physical or financial component. This is particularly the case in the agricultural sector, in which a greenhouse-in-a-box or sensors are complemented by digital advisory services (e.g. Kheyti and Zenvus). Similarly, microfinance institutions such as Musoni combine their platforms for financial services with professional advice, in a hybrid product that is digitally enabled.

The business models differentiate themselves by easing access to a new service or good. This indicates that they consider that access is an important barrier for low-income customers. Consequently, firms that find a new way of providing such access, through online platforms or improved supply chains, can access previously unserved customers. For example, in South Africa, Yoco provides point-of-sale hardware and management software to shops that previously conducted their sales and inventory manually.

A prolonged customer relationship is a standout factor of most of the businesses analysed. Through, for example, continued advice, upgrading within an electronic product environment or lease-to-own schemes, connections between firms and customers can extend beyond the initial sale (e.g. Farm Better, Kheyti and Mobihealth International and, with regard to the upgrading of electronic products and lending through lease-to-own schemes, Fenix International and Zola Electric). However, closer customer relationships do not always imply close customer involvement in the creation process of products or services. Customer involvement appears to be more common in cases where the business is a multisided platform and the customer side is another business, such as Lenddo, a firm that creates credit scores, and the recruitment platform Shortlist. Suppliers, on the other hand, are involved in settings in which they provide specific expertise such as medical advice or are the service providers for welfare programmes (e.g. Haqdarshak and Mobihealth International).

The key characteristics of the businesses with regard to value creation are introducing an innovation or supplying products not produced by the firm. The innovation takes the form of either process innovation or product innovation through the firm's internal research and development. An example of process innovation is seen with M Pharma, which has streamlined pharmaceutical supply chains in several countries in Africa. By encouraging pharmacies to join a larger network, bulk-buy medication and streamline inventories, prices have been reduced by up to one third and the supply stream improved. Examples of product innovation through research and development are e-learning platforms that allow for a personalized learning experience through proprietary artificial intelligence algorithms (e.g. Muskaan Dreams and Tai School).

Most of the business ideas have a clear profit focus while selling for relatively low prices. Such a pricing level is possible by aiming for large customer bases, such as the mobile telephone market, and by making product and service delivery as efficient as possible, to increase margins. Firms that do this are in different sectors, for example, various learning platforms, Musoni in banking and Yoco as a point-of-sales system.

Beyond the descriptions of the characteristics of business models, there are policy implications that arise from them. The dominance of digitally enabled businesses emphasizes the need for a functional enabling environment to which Governments can contribute, namely, involving widely accessible mobile networks, including broadband Internet capacity and appropriate legislation, such as with regard to data protection and privacy laws. In addition, as many of the businesses analysed have the supply of products at their core, improving infrastructure, such as roads, to support logistics is vital.

Furthermore, many of the firms identify a lack of financial resources as a bottleneck to attracting more customers. Therefore, they offer lease-to-own schemes (e.g. solar panel providers) or front the cost of the merchandise (e.g. M Pharma, which provides medication to pharmacies and only charges for the portion that is actually sold to patients, thereby reducing the pharmacies' cost of maintaining stock). These elements are important to support businesses, but also have implications for legislation; the consumers that take advantage of financing options offered by firms need to be sufficiently protected from predatory lending behaviour. In addition, firms need relatively easy access to financing to support their business models and the finance that they can pass on to their customers.

Finally, as there is a profit motive, there is scope for taxation from which the public sector can benefit. However, the respective bureaucracy should support this by, for example, easing procedures such as those involved in filing taxes.

C. SUSTAINABILITY AND BUSINESS

The awareness that poverty alleviation and environmental sustainability can and should be aligned is ingrained in the 2030 Agenda for Sustainable Development. Inclusive business ideas often have sustainability at their core or at least as an aspect of their strategy.

Sustainability can be targeted in different ways, for example, with regard to agriculture. Improved agricultural practices can lead to better yields. In addition, climate change and environmental degradation make adaptation essential. Mobile advisory services for smallholding farmers can support the resilience of farming practices that are relevant to the local environment and thereby prevent further land degradation and support recovery (e.g. Farm Better). Complementing advice with high-quality inputs is a more holistic business and farming approach that simultaneously addresses the goals of poverty alleviation and environmental responsibility (e.g. Kheyti). Furthermore, frontier technologies can support sustainability through improved observation tools. Internet of things sensors combined with drone-enabled imaging can help improve farming practices and curb outbreaks of pests through earlier observation and data analytics that were not accessible to individual farmers until recently.

Around 840 million people still do not have access to electricity. Furthermore, 2.8 billion people do not have access to clean energy sources for cooking (UNCTAD, 2019d). This has important implications for health, society and the environment. Consequently, alternative forms of energy are vital to achieving the Sustainable Development Goals, in particular Goal 7. Off-grid solar-powered energy solutions, such as those provided by Fenix International and Zola Electric, contribute to achieving this Goal by giving customers access to solar-based solutions, including low-energy electronics.

In future, consumption and production must become more sustainable. Reducing waste and enhancing the circular economy is one aspect of this. For example, Mr. Green Africa helps redesign value chains such that technology helps to streamline them, with waste collectors an important part of the process, and produces recycled raw material for plastic manufacturers. Project Circle G contributes to the circular economy by providing alternative uses for recycled plastic, aiming to produce low-cost prosthetics from recycled plastic waste that can be made in developing countries, thereby contributing to both economic and environmental sustainability.

D. THE CHALLENGE OF REACHING THE EXTREME POOR

This section examines how innovative business models using frontier technologies could reach people living on less than $1.90 per day, the international poverty line (Ferreira et al., 2016). Poverty remains an issue despite important strides in poverty reduction in the past 25 years. Over 700 million people remain below the poverty line, excluded from resources sufficient to accessing education, health and other basic services (United Nations, 2018a). Families live in precarious conditions, in rural areas or squatter settlements in urban areas, usually without access to electricity, clean water and/or sanitation, with few possessions and expending all of their income on food. This makes them vulnerable to numerous hazards. They are also time-poor, spending most of their day in long hours of work and fetching water and collecting wood for cooking. They may have an older model mobile telephone, but access to the Internet is unaffordable.

Given these challenging conditions, business models that use frontier technologies to deliver products and services for an entire community at once could be more effective, such as in the case of renewable mini-grid energy projects, community health services supported by frontier technologies and disaster risk reduction assessments through the use of drones and machine learning (box 6).

Businesses using frontier technologies and considering affordability and access can help improve the life of the extreme poor, yet market forces alone are not sufficient.

First, establishing a legal identity, under programmes such as Aadhaar in India, is vital in order to integrate marginalized individuals into society (Gelb and Diofasi Metz, 2018). Legal identity increases the chances of overcoming poverty by opening access to social programmes, services such as mobile telephones or public utilities and financial services such as loans.

Second, as many of the mentioned business models rely on mobile telephones and digital platforms, education is vital. Frontier technologies require sufficient literacy levels to navigate the platforms and digital skills to be aware of the risks associated with financial or confidential transactions online (UNCTAD, 2019e).

Box 6
Building resilience by making frontier technologies work for the vulnerable

The number of technologies that address the needs of vulnerable populations is growing.

In Armenia, the firm Georisk uses data from multiple sources and machine learning to assess the risks from earthquakes. A particular vulnerability during earthquakes is with regard to buildings that cannot withstand the shocks, which makes urban areas more dangerous. Georisk can produce detailed risk maps, including information on the daytime and night-time occupancy rates of buildings and on impacts on infrastructure such as roads and electricity, gas and water supplies. The resulting maps aim to inform urban resilience planning.

In Uganda, lightweight drones have mapped the environment around refugee settlements in the district of Isingiro. The maps integrate infrastructure and settlement information with data on climate and natural hazards to support risk-informed decision-making. This is in line with work in Uganda to implement the Sendai Framework for Disaster Risk Reduction 2015–2030.

Similarly, but with a global focus, One Concern, a partner of the United Nations Office for Disaster Risk Reduction, combines artificial intelligence with physical science to predict and quantify the impact of natural disasters, to support resilience in communities and for companies.

Source: Contribution from the United Nations Office for Disaster Risk Reduction, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con19_UNDRR.pdf.

Some businesses must rethink their models to deskill tasks for consistent service provision. This increases the potential workforce available to perform tasks that ensure consistent supply or service delivery. For example, prosthetics generally require several fittings and are relatively expensive to produce. For consistent delivery to the poor in a developing country setting, fittings need to be accelerated, as recipients cannot spend days in distant hospitals testing their prosthetics. Consequently, the prosthetics must be made in such a way that fittings require minimal effort and can be done by those that have undergone relatively little training (e.g. Project Circle G).

IV. THE ROLE OF SCIENCE, TECHNOLOGY AND INNOVATION POLICIES

STI policies help create an environment for harnessing frontier technologies, that can help put countries on socially and environmentally sustainable development paths.

In many countries, strategies for the development of frontier technologies have recently been proposed to guide the use, adoption, adaptation and development of such technologies. For example, in Belgium, public authorities have developed a federal strategy for digitalization (Digital Belgium) and regional strategies (Industrie 4.0, Digital Wallonia and Be Digital Brussels), mostly comprised of projects involving cross-border cooperation at the regional level, often connected to European Union programmes.[4] In 2018, Brazil established the National System for Digital Transformation and the Digital Transformation Strategy, an umbrella policy aimed at harmonizing and coordinating different government initiatives on digital issues within a coherent framework and proposing strategic actions under the perspective of the Sustainable Development Goals.[5] The national digital economy of the Russian Federation programme aims at economic development based on the application of ICT through demand support, support for Russian Federation high technology companies and the improved competitiveness of domestic digital products, including at the international level.[6] In Turkey, the Digital Turkey Road Map is a comprehensive strategy that covers human capital, technological capacity, infrastructure, suppliers, consumers and governance.[7]

Many STI policy instruments could further provide directionality to technological change towards inclusive outcomes. Some critical policy instruments target education and training in frontier technologies.

For example, the Digital Turkey Road Map aims to not leave anyone behind, by training digital technology users in continuous education centres and thematical technical colleges, increasing digital technology development programmes in universities, improving the digital literacy of teachers at every level, supporting doctoral-level degrees in digital technologies, supporting the matching of digitally competent human capital with the needs of industry, improving awareness of digital transformations and improving collaboration between digital transformation stakeholders.[8]

STI policies should promote basic literacy and the development of basic digital skills (box 7). It is vital to address the gender imbalance in the fields of science, technology, engineering and mathematics (STEM), in both technical skills and entrepreneurship that, among many other negative outcomes, also impact the widespread adoption of new technologies (box 8).

Box 7
Belgium, Latvia, Lebanon, Turkey, the United Arab Emirates and the United States: Shaping the workforce of the future

Education needs to be relevant to recent technological developments and prepare students for future changes. One approach is to ensure closer collaboration between the education and private sectors.

In Belgium, Technopolis, a science centre funded by the Government, aims to attract more young people into sciences by increasing enrolment, graduation and advancement. One of its programmes, the STEM academy, attempts to address the skills shortage in scientific fields by encouraging interest in science through a network of STEM-related extracurricular activities for young people, to make STEM fields and related twenty-first century skills accessible to as many as possible. Furthermore, the Vet Toolbox initiative, co-funded by the European Union and the development agencies of Belgium, France, Germany, Luxembourg and the United Kingdom, supports partner countries in shaping their vocational education and training systems to make them relevant to recent technological developments. A Vet Toolbox hackathon identified closer collaboration with the private sector as essential and developed the idea for an application that would bring together the public sector, the private sector and potential trainees, to bridge the information gap between these stakeholders.

[4] Contribution from the Government of Belgium, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con32_Belgium.pdf.

[5] Contribution from the Government of Brazil, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con26_Brazil.pdf.

[6] Contribution from the Government of the Russian Federation, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con13_RussianFederation.pdf.

[7] Contribution from the Government of Turkey, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con04_Turkey.pdf.

[8] Ibid.

In Latvia, in 2015, Riga Technical University established the Engineering High School, the first general secondary education institution in Latvia linked to a university. The school cooperates closely with the private sector and offers a general education track in mathematics, science and technologies. During holidays, the school offers internships at cooperating partner firms. Students can attend university courses, work in laboratories and attend guest lectures given by leading researchers. Overall, students receive training in advanced research skills that prepare them for tertiary education degrees and research careers in the sciences.

In Lebanon, the private initiative All Girls Code offers a technology immersion programme for girls during which they learn the basics of website development and, during hackathons, develop ideas for applications, often with a social purpose. The programme aims to raise the interest of girls in STEM fields and is followed up with mentoring, scholarship and career opportunities.

In Turkey, to address the skills mismatch between higher education and the private sector, the Scientific and Technological Research Council launched the 2244 Industry Doctorate Programme, which targets an increase in the share of researchers in the industry through closer university and industry collaboration. The doctorate is covered by a scholarship and the Council provides three years of employment support following graduation. Furthermore, the Ministry of Industry and Technology supports Try It and Do It Workshops that introduce middle and high school students to coding, artificial intelligence and robotics, to stimulate the interest of youth in technology relevant to industry.

In the United Arab Emirates, the One Million Arab Coders initiative of the Government is an e-learning platform for digital skills to prepare the labour force for the skills of the future.

In the United States, the strategy for STEM education aims to prepare the workforce of the future by building strong STEM literacy and increasing diversity and improving inclusion in these fields. Furthermore, several private initiatives specifically target disadvantaged groups and relevant digital skills. Byte Back is a computer certification programme aimed at helping low-income and unemployed people to improve their skills and find employment; Spark Technology is a summer programme for school children in Washington, D.C.; and Girls Who Code encourages girls to learn programming and to pursue careers in the field.

Sources: Contributions from the Governments of Belgium, Latvia, Turkey and the United States, as well as the Economic and Social Commission for Western Asia, available at https://unctad.org/meeting/commission-science-and-technology-development-twenty-third-session-virtual-informal-meeting.

Box 8
Brazil and the United States: Women, digital skills and entrepreneurship

The Government of Brazil launched a digital entrepreneurs project in March 2019, which provides training and capacity-building to women to encourage their entrepreneurship in innovation sectors. The target is to increase the share of women in the technology workforce, which is currently around 20 per cent.

The United States invests in several programmes worldwide to encourage women entrepreneurs. The Women Entrepreneurship Finance Initiative Facility aims to increase funding and investment in women's businesses by directing private sector investment towards them. The initiative is complemented by technical assistance, such as skills training. The Overseas Private Investment Corporation has a programme that, in 2018, committed $1 billion to women's businesses in developing countries. The Women's Global Development and Prosperity Initiative, launched in February 2019, plans to empower 50 million women in developing countries by 2025, with entrepreneurship as one pillar.

Sources: Contributions from the Governments of Brazil and the United States, available at https://unctad.org/meeting/commission-science-and-technology-development-twenty-third-session-virtual-informal-meeting.

Technological foresight and evaluation instruments are used to better understand technological paths and potential social, economic and environmental impacts. For example, one of the strategic actions in the Digital Transformation Strategy of Brazil is to evaluate the potential social and economic impact of disruptive digital technologies and to propose policies that can mitigate their negative effects and maximize positive results.[9]

STI policies also include support for networks among firms and the main actors of the national innovation system, which are critical for innovation. For example, in Belgium, several industry-led initiatives have been launched to support companies in their digital transformation and to adopt new technologies and boost synergies and innovation. Examples include the programme "Made different: Enabling factories of the future"; cluster policies, including the network of innovation clusters and innovative business networks; the living laboratory programme; and Digital Health Valley.[10]

[9] Contribution from the Government of Brazil, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con26_Brazil.pdf

[10] Contribution from the Government of Belgium, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con32_Belgium.pdf.

As technology-based products and services should be affordable to low-income customers and accessible to the larger population, STI policies should target the reduction of the cost of critical and vital technology-based services. For example, the Russian Federation has started pilot projects of domestically produced solutions based on end-to-end digital technologies in priority areas such as health-care systems, paramedic and obstetrical stations, secondary schools, fire stations, post offices and police stations.[11]

Since STI activities in some areas have spillover effects that benefit all of society, STI policies could guide innovation using frontier technologies towards increasing social welfare. For example, in the Islamic Republic of Iran, the Government has considered the balance between the benefits and potential negative externalities of new technologies, such as by building advocacy coalitions in favour of innovation and sustainable development in the transportation sector (box 9).

Box 9
Islamic Republic of Iran: Local digital transportation platforms

Policymakers should understand the advantages and disadvantages of new technologies.

In the Islamic Republic of Iran, the Vice-Presidency for Science and Technology supports local digital transportation platforms because they provide smart and low-cost services. The Vice-Presidency also considers negative aspects, for example, the impact of such platforms on traffic, the rights of drivers and the quality of jobs created and promoted by the platforms, that is, companies that do not classify their drivers as employees. In addition, the issue of competition and trust within this industry is a policy concern. The Vice-Presidency and other regulatory bodies attempt to mitigate negative impacts on society. A unique aspect of this process is the close collaboration of the Vice-Presidency and transportation network companies, to develop an innovation ecosystem and to use the capacity and market of transportation network companies to shape a green transportation and electronic vehicle industry in the country. Transportation network companies provide incentives for riders who use electronic vehicles.

Source: Contribution from the Government of the Islamic Republic of Iran, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con14_Iran.pdf.

STI policies on reducing inequalities should focus on strategies and mechanisms that create an enabling environment for innovative approaches, including pro-poor, inclusive, below-the-radar, frugal, bottom-of-the-pyramid, grass-roots, market-oriented and social innovation. To facilitate the development of appropriate business models for scaling up inclusive innovation using frontier technologies, to help achieve the Goals, STI policies should provide incentives to attract private finance to innovative and inclusive businesses using frontier technologies, through matching funds, risk mitigation and other forms of support for private sector investments.

Policies should also foster the engagement of academia and civil society organizations with the private sector to facilitate the scale-up of solutions. STI policies should give due consideration to science parks, incubators (in more technologically advanced countries), accelerators, innovation laboratories and marketplaces to incubate innovative ideas, foster innovation clusters and facilitate experimentation and faster technology diffusion. For example, the Government of Brazil, in partnership with private institutions, has collected expertise from hundreds of industrial innovation specialists in *Perspectives on Advanced Manufacture by Brazilian Experts*, which highlights the importance of new open laboratories, dedicated to developing digital industry technologies, which consider the combination of such technologies to generate unprecedented opportunities for competitive manufacturing in Brazil.[12]

At the same time, STI policies should promote the scale-up and dissemination of successful innovations that emerge from such innovation hubs, to reduce inequalities created by the geographic concentration of technological capabilities.

[11] Contribution from the Government of the Russian Federation, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con13_RussianFederation.pdf.

[12] Contribution from the Government of Brazil, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con26_Brazil.pdf.

V. INTERNATIONAL COLLABORATION

Rapid technological change impacts all countries and segments of society. International collaboration is therefore critical to ensuring inclusive and sustainable outcomes. This chapter summarizes some of the initiatives that member States, the United Nations and the international community have taken to mitigate the risks from rapid technological change and to maximize the benefits.

A. RESEARCH COOPERATION AND SCIENCE–POLICY INTERFACE

Foundational public research remains vital to ensuring that emerging technologies are developed with inclusiveness and sustainability in mind. For example, the Horizon 2020 programme of the European Union has two initiatives that do so. The European Innovation Council Pathfinder Pilot of the European Commission offers grants for radically new technologies to research consortiums from member States of the European Union and associated countries. Topics include artificial intelligence and zero-emission energy generation.[13] In addition, Responsible Research and Innovation under Horizon 2020 implies that research processes and outcomes should be aligned with the needs and values of society and anticipate the consequences and, therefore, the initiative aims to make innovation more inclusive.[14]

In Belgium, the Flemish Institute for Technological Research designed the Global Conferences on Science, Technology and Innovation to bridge the gap between cutting-edge technological development and international policymaking.[15] It also provides informal support to the United Nations Technology Facilitation Mechanism for the achievement of the Sustainable Development Goals and the transition to less carbon-intensive and less resource-intensive and more resilient, economical and inclusive sustainable development models.

B. CAPACITY-BUILDING

International cooperation contributes to shaping STI policies that can steer technological change towards sustainable development. For example, through international forums and mechanisms, Governments and other stakeholders can learn from each other's experiences and identify new ways to harness frontier technologies for sustainable development. Governments, practitioners and the private sector have held extensive discussions on this topic at sessions of the Commission on Science and Technology for Development, the Multi-Stakeholder Forum on STI for the Sustainable Development Goals and the artificial intelligence for good summit of the International Telecommunication Union (United Nations, 2018c; United Nations, 2019b; High-Level Political Forum, 2019). Through such discussions, Governments can better understand the potential of new technologies in tackling societal challenges, the institutional changes needed to facilitate innovation for sustainable development and the international cooperation mechanisms that could be put in place to support such initiatives.

Several United Nations agencies have supported member States in strengthening their capacities to develop and implement inclusive STI policies, such as the STI policy reviews conducted by UNCTAD; and the STEM and gender advancement project and the global observatory on STI policy instruments of the United Nations Educational, Scientific and Cultural Organization (box 10). The United Nations also supports member States through demonstration programmes that disseminate best practices in the use of frontier technologies for inclusive and sustainable development, such as through the global eco-industrial parks programme of the United Nations Industrial Development Organization (box 11); and in fostering innovation in addressing specific Sustainable Development Goals, such as through the youth entrepreneurship and innovation network of the Food and Agriculture Organization of the United Nations (box 12).

[13] See https://ec.europa.eu/research/eic/index.cfm?pg=funding.

[14] See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation.

[15] See https://2019.gstic.org/.

Box 10
UNCTAD and the United Nations Educational, Scientific and Cultural Organization: Policy analysis for inclusive science, technology and innovation policies

UNCTAD conducts STI policy reviews in developing countries to assess their national innovation systems and help build their capacities to design and implement STI policies aligned with their national development strategies and the Sustainable Development Goals. UNCTAD has conducted reviews in 17 developing countries and, as at December 2020, was conducting reviews in the Dominican Republic, Ethiopia, Uganda and Zambia. Other countries that have indicated their interest in a review include Botswana, Nigeria and Viet Nam.

The United Nations Educational, Scientific and Cultural Organization is undertaking several projects that contribute to international cooperation and enhancing national ecosystems for innovation, including the STEM and gender advancement project and the global observatory on STI policy instruments. Both projects propose assessment tools to identify gaps in policies and actions linked to rapid technological change. The STEM and gender advancement project provides tools to Governments that aim to reduce the gender gap in STI fields at all levels of education and in research by increasing women's visibility, involvement and recognition. To date, the project has been carried out in eight countries to assess gender inequality in STEM fields and new pilot projects are being conducted in Argentina, the Gambia, the Sudan and Uruguay, as well as the province of Quebec, Canada, to adjust their STI policies to remove barriers. The global observatory maps national STI environments and policies to identify gaps, allowing for more evidence-based decision-making in the STI policy domain, including with regard to policies on women and youth in STI and traditional and indigenous knowledge.

Sources: UNCTAD and contribution from the United Nations Educational, Scientific and Cultural Organization.

Box 11
United Nations Industrial Development Organization: Global eco-industrial parks programme

Production methods need to become cleaner and more efficient in order for countries to achieve sustainable development. The global eco-industrial parks programme of the United Nations Industrial Development Organization and the Switzerland Secretariat for Economic Affairs aims to demonstrate the sustainability and benefits of making industrial parks greener through improved resource productivity and by making businesses more inclusive with regard to social and economic performance. The programme is being conducted in Colombia, Egypt, Peru, Ukraine and Viet Nam. In addition to collaborating with businesses to improve their resource efficiency, as a starting point for scaling up eco-industrial production, the country-level interventions have a wider capacity-building component to ensure their sustainability into the future. The programme collaborates with local universities to inform national experts that can create a national platform to promote and scale up the eco-industrial park approaches.

Source: Contribution from the United Nations Industrial Development Organization, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con10_UNIDO.pdf.

Box 12
Food and Agriculture Organization of the United Nations: Youth entrepreneurship and innovation network

The Food and Agriculture Organization of the United Nations has implemented several programmes to support youth entrepreneurship and innovation.

The Hack Against Hunger Innovation Challenges bring together diverse public and private sector experts to mentor young innovators, to develop high-potential digital solutions to challenges faced in food and agriculture systems, including through the use of frontier technologies and sustainable business models for development and adoption. The Innovation Challenges have been launched in partnership with other development agencies and universities and closely linked to high-level regional and global conferences, to increase advocacy and awareness of the need to strengthen national capacity to innovate and invest in agribusiness, in particular in relation to youth employment.

With a view to increasing engagement beyond hackathons, the Organization has invited several of the innovators that have won the Innovation Challenges to Digital Innovation and Entrepreneurship Workshops, to attend conferences, network and participate in a bootcamp at which they meet with technical experts in the areas related to their innovations, to receive hands-on advice and share insights on key areas in digital agriculture.

The Youth Entrepreneurship and Innovation Incubator of the Organization and KT Corporation is a private sector partnership, focusing on digital technologies, including frontier technologies, for agriculture and on engaging youth in smart farming and agribusiness, to strengthen national capacities in Asia through mentorship and training.

Source: Contribution from the Food and Agriculture Organization of the United Nations (see www.fao.org/about/meetings/youth-in-agriculture/hack-against-hunger/en/, www.fao.org/e-agriculture/node/15702 and www.fao.org/news/story/en/item/1197915/icode/).

International cooperation also contributes to increasing understanding of the possible impacts of frontier technologies on societies, economies and the environment. Given the complexity and speed of technological change, such change could outpace the capacity of Governments to fully understand its consequences. Assessing the

impact of frontier technologies is therefore vital. In this regard, the Commission on Science and Technology for Development and the Technology Facilitation Mechanism, in response to General Assembly resolutions 72/242 and 73/17, have considered, in a coordinated manner within their respective mandates, the impact of rapid technological change on sustainable development (United Nations, 2019c; High-Level Political Forum, 2019). The Technology Facilitation Mechanism provides a platform for inter-agency country-level engagement, as well as global multi-stakeholder deliberations and consensus-building on STI for the Sustainable Development Goals, including emerging technologies (box 13).

Box 13
United Nations Technology Facilitation Mechanism

The Technology Facilitation Mechanism was established under the Addis Ababa Action Agenda to support the achievement of the Sustainable Development Goals and launched by the General Assembly in 2015 under the 2030 Agenda for Sustainable Development. The Mechanism comprises an Inter-Agency Task Team on STI for the Sustainable Development Goals, the Multi-Stakeholder Forum on STI for the Sustainable Development Goals and an online platform. The Task Team is co-convened by UNCTAD and the Department of Economic and Social Affairs. As mandated, the Forum provides a venue for facilitating interaction, matchmaking and the establishment of networks between relevant stakeholders and multi-stakeholder partnerships to identify and examine technology needs and gaps, as well as to help to facilitate the development, transfer and dissemination of relevant technologies, to help achieve the Goals. As part of this work, several initiatives are under way, such as that of STI road maps for the Goals. Issues related to emerging and frontier technologies are also deliberated annually at the Forum.

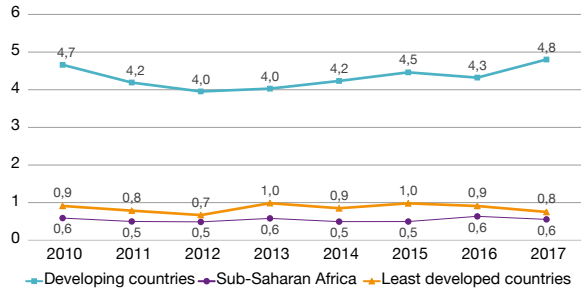
Source: Contribution from the Department of Economic and Social Affairs, available at https://unctad.org/system/files/non-official-document/CSTD_2019_Ipanel_T1_Inequality_con22_DESA.pdf.

The Commission on Science and Technology for Development, as the focal point in the United Nations system for discussions on STI for development, has addressed the impact of rapid technological change on sustainable development in its recent sessions. In particular, in 2019, the Commission presented recommendations to the Economic and Social Council that encouraged the international community to advance its understanding of the risks and benefits, as well as policy options for steering innovation in ways that would leave no one behind. The Commission has encouraged States to undertake strategic foresight and technological assessment initiatives to better understand the socioeconomic and environmental implications of new and innovative technologies (see Economic and Social Council, 2019). Another international cooperation activity that could be promoted in the context of the Commission is the creation of a network of social entrepreneurs to facilitate the dissemination of innovative business models using frontier technologies to address developmental issues. First movers are important because they show how frontier technologies could be applied in a way that is not only effective in achieving the Goals but also economically viable and demand driven. However, equally important is the dissemination of successful business models that create an ecosystem of innovative businesses addressing different aspects of the Goals and reaching the scale required to promote enduring progress towards achieving the Goals. Such a network should engage businesses that offer frontier technology-based products and services that contribute to achieving the Goals. The engagement of the business community will enable the scale-up of inclusive and sustainable innovative solutions to a level that could promote the transformations required to achieve sustainable development. At the national level, Governments could promote a network of social businesses, entrepreneurs and practitioners. At the international level, the Commission on Science and Technology for Development could foster international networks in collaboration with other stakeholders.

C. OFFICIAL DEVELOPMENT ASSISTANCE

Through technical cooperation programmes, international collaboration activities have supported countries in building national STI capacity, including in frontier technologies. Technical cooperation delivered through official development assistance (ODA) is an important source of technical and financial support in developing countries. However, ODA targeting some of the areas that more directly contribute to building STI capacities in developing countries has not increased in the past decade. In 2010, $4.7 billion in ODA commitments to developing countries was reported in the following sectors: post-secondary education, ICT, industrial development, technological research and development, research and scientific institutions and import support for capital goods. ODA was reduced to $4.0 billion in 2012 and 2013 and has recently recovered, reaching $4.8 billion in 2017, yet this is only about the level of ODA in 2010 (figure 5). Of greater concern is that ODA in these sectors directed to some of the countries with the lowest STI capabilities decreased in this period. ODA in these sectors directed to the least developed countries decreased from $0.9 billion in 2000 to $0.8 billion in 2017 and, with regard to sub-Saharan Africa, remained relatively unchanged, at $0.5 billion–$0.6 billion.

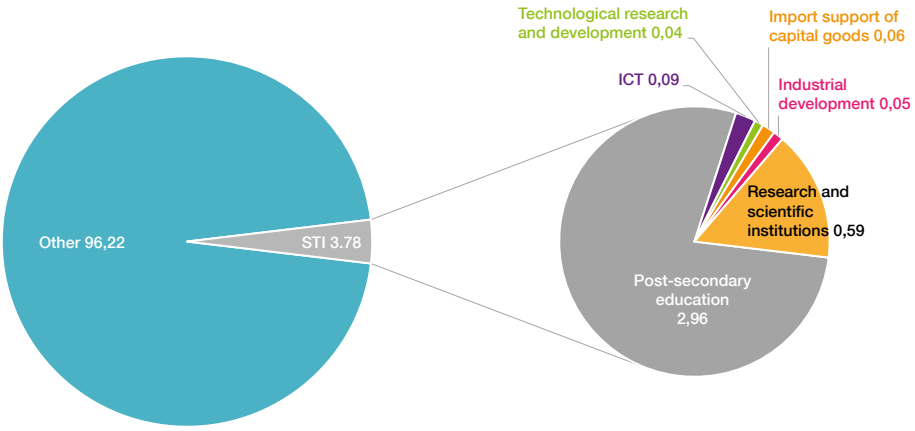
Figure 5
Official development assistance in sectors associated with scientific, technological and innovative capacity, selected groups of countries
(Billions of dollars, constant prices)



Notes: Includes ODA commitments reported with regard to post-secondary education, ICT, industrial development, technological research and development, research and scientific institutions and import support for capital goods; the group of the least developed countries includes Cabo Verde (graduated in 2007), Maldives (graduated in 2011) and Samoa (graduated in 2014).
Source: UNCTAD calculations, based on data from the creditor reporting system of the Organization for Economic Cooperation and Development.

Furthermore, in 2017, only 3.78 per cent of ODA commitments to developing countries was reported under sectors associated with STI with, by sector, 2.96 per cent dedicated to post-secondary education; 0.59 per cent, to research and scientific institutions; 0.09 per cent, to ICT; 0.06 per cent, to import support for capital goods; 0.05 per cent, to industrial development; and 0.04 per cent, to technological research and development (figure 6). The levels of ODA dedicated to these sectors need to be increased, as these are unquestionably key sectors for increasing the capacity of developing countries to harness STI for sustainable development and they have long-lasting spillover effects in all areas of the Sustainable Development Goals.

Figure 6
Official development assistance: Share in sectors associated with scientific, technological and innovative capacity, developing countries, 2017
(percentage)



Source: UNCTAD calculations, based on data from the creditor reporting system of the Organization for Economic Cooperation and Development.

VI. POLICY CONSIDERATIONS

A. CREATING AN ECOSYSTEM FOR INCLUSIVE AND SUSTAINABLE INNOVATION IN FRONTIER TECHNOLOGIES

Develop national digital agendas: Governments should develop national digital agendas to close the digital divide in access and skills by leveraging ICT infrastructure and improved Internet access with fixed or mobile broadband and by promoting and improving user capabilities and Internet access culture through the education system among youth and through ad hoc initiatives for the overall population, particularly among women and girls, as well as disadvantaged groups.

Engage local industry: Governments should engage local industry in the continuous improvement of curricula through participation in advisory boards, practical courses, technical and vocational education, training offers and research projects.

Upgrade the skills and knowledge of innovators: Governments should formulate policies and strategies that incorporate upgrading the skills and knowledge of researchers and innovators for the development of frontier technologies for sustainable development.

Build capacity in the application of frontier technologies for sustainable development: Governments should promote capacity-building programmes in the application of frontier technologies for the development of solutions, products and services for sustainable development.

Promote lifelong learning and retraining programmes: New technologies demand new skills; the labour force should therefore be trained to acquire such skills throughout their careers. Governments should promote adult learning and retraining programmes that help match the evolving demands of the labour market and facilitate transitions across jobs.

Ensure the required legal and regulatory system: Governments should ensure that the legal and regulatory system encourages the ethical use of frontier technologies in the public and private sectors, for example, by regulating issues of data ownership and privacy and by requiring technological impact assessments of public sector technology solutions targeting vulnerable people.

Strengthen research, development and innovation in frontier technologies: Governments should formulate policies and strategies that promote and strengthen research, development and innovation in frontier technologies for sustainable development.

Reinforce technology transfer and strengthen linkages: Governments should reinforce technology transfer at the national and regional levels and therefore strengthen linkages and collaboration between academia, research centres and the private sector for the development of frontier technologies.

B. PROVIDING DIRECTIONALITY TO TECHNOLOGICAL CHANGE AND MITIGATING RISKS

Set directions, basic principles and ethical guidelines: Given the rapid development of technologies and based on foresight and technological assessments, Governments should play a supporting role by setting the strategic direction in the application of new technologies, basic principles and ethical guidelines, while involving the private sector, academia and other stakeholders in the policymaking process, making full use of the possibilities that data-sharing, reuse and cross-border data flows can provide.

Facilitate adaptation to the local context and culture: Governments should promote the localization of Sustainable Development Goals-related solutions based on frontier technologies to the context and culture (including languages, values and norms), with the participation of local knowledge producers and innovation stakeholders.

Establish periodic dialogues: Governments should establish periodic dialogues among various stakeholders (the Government, academia, research centres, the private sector and professional associations) on the national and regional priorities in frontier technologies and potential national projects.

Engage social and labour-related institutions: Governments should engage policymakers from ministries of social development, ministries of labour and labour unions in the national planning of digital development agendas (and, vice versa, engage the digital sector in national labour planning), to ensure an appropriate level of understanding of the digital

disruptions and transformations in the national labour market and to plan proactively to mitigate the associated risks through regulation.

Promote decent digital jobs: Governments should promote decent digital jobs, fair compensation and work–life balances for digital employees and freelancers, including the potential establishment of syndicates for digital workers.

Facilitate labour mobility: Governments should develop policy instruments and mechanisms to facilitate retraining and the sectoral mobility of workers affected by rapid technological change.

Establish digital platforms: Governments should establish digital platforms to enhance the links between job seekers and employers and to provide updated information to users about the needed skills and available training centres.

Facilitate fair relations between workers and employers: Governments should facilitate fair relations between workers and employers in the digital economy, including by offering a legal framework that strengthens the bargaining power of workers, and makes it easy for employers to hire and adjust the size of the workforce; and providing policies for workers to be trained to develop new skills as they progress in their careers.

Develop scenarios and prepare for changes: Governments should develop scenarios and modalities for preparing the workforce and the business sector for expected changes in labour dynamics.

C. ENHANCING INTERNATIONAL COOPERATION

Develop multilevel policies: The international community should assist the development of multilevel policies, with subsequent evaluations and adjustments, taking into account the rates and characteristics of development in different countries, to maximize the benefits associated with rapid technological change and mitigate the risk that such technologies may widen or create new inequalities within and across countries.

Discuss and formulate ethical principles: The international community, including through the Commission on Science and Technology for Development, should discuss and formulate ethical principles for the private sector, including multinational companies, on the development of solutions, goods and services using frontier technologies that are inclusive and do not increase inequalities.

Connect innovative firms worldwide: International organizations and Governments should promote the collaboration of start-ups and innovative enterprises from different parts of the world for innovation and social benefits.

Establish a dialogue: The international community, including through the Commission, should establish a dialogue among various stakeholders in developed and developing countries on the impacts of and challenges and issues related to frontier technologies, while ensuring a voice for developing countries on issues related to the governance of frontier technologies.

Share experiences: The Commission should continue to promote and facilitate the sharing of experiences, through its sessions, meetings, training sessions, workshops and website, as well as curated documents and other materials, on the challenges faced and solutions found in dealing with the effects of rapid technological change, for countries to draw on and implement according to their respective national priorities and circumstances.

Share information on successful business models: The Commission, through UNCTAD, should promote the establishment of a network of social innovators and practitioners to facilitate the collection of better data and the creation and adoption of successful business models of frontier technology-based solutions for inclusive and sustainable development.

Encourage a volunteer mentorship mechanism: The Commission could sponsor a volunteer mentorship mechanism to share experiences, by which volunteer mentors in member States with experience in rapid technological change could provide advisory services to other States upon request.

Assist in bridging multidisciplinary digital divides: The international community, including through the Commission and the Multi-Stakeholder Forum on STI for the Sustainable Development Goals should further commit to assisting Governments and partners in setting a systematic and holistic approach to bridging multidisciplinary digital divides, to ensure that everyone benefits from the emerging digital society through increased access to infrastructure and increased access to knowledge through specialized platforms, training and finance, among others.

Harness existing global platforms: The international community, including through the Commission, should harness existing global platforms, including relevant United Nations forums, to conduct dialogues at the national, regional and global levels, between digital companies and digital workers and other stakeholders, to devise mechanisms for minimizing the risks and maximizing the benefits of rapid technological changes for all.

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ANNEX
SELECTED INNOVATIVE BUSINESS MODELS PROVIDING INCLUSIVE AND SUSTAINABLE PRODUCTS AND SERVICES

			Degree of digitization			Product type								Strategy for differentiation								Target customers			Value delivery process				Sourcing			Third parties involved				Value creation process					Revenue Model					Pricing strategy				Profit intent		Direct profit effect			
			Purely digital	Digitally enabled	Not necessarily digital	Physical	Financial	Professional advice	Intellectual property	Hybrid	Quality	Customization	Combination	Accessibility/convenience	Price	Network effects	Specific new customer segment	Lock-in existing customers	Other companies (B2B)	Brand and marketing	Sales channel	Sales model	Customer relationship management	Make	Buy	No impact on sourcing	Suppliers	Customers	Competitors	Multiple parties	No impact on third parties involved	Research and design	Supply	Production	Multiple steps	Sell	Lend	Intermediate	Advertising	Premium	Cheap	Dynamic	Non-transparent	For profit	not for profit	Increased revenue	reduce cost	multiple effects	No direct profit impact
Company	Sector		7	16	1	13	15	16	9	19	17	11	19	18	17	6	22	3	6	9	5	11	21	20	4	2	6	8	0	2	12	16	15	12	15	18	5	8	0	1	14	4	8	20	2	9	6	3	12
Babyl	health			x		x	x	x		x	x	x	x	x	x	x	x							x	x										x	x				x			x	x						
Bloc	employment		x						x	x		x					x			x				x							x									x									
Bridge International Academies	education		x					x	x					x			x														x										x								
Capway	financial		x				x	x		x				x	x	x	x			x			x	x										x	x	x					x			x					
Connected Agriculture Platform for Punjab (CAPP)	agriculture						x	x		x			x		x	x	x					x	x	x			x																					
FarmBetter	agriculture		x					x			x			x	x	x	x						x	x				x						x	x													
Fenix	energy					x	x			x				x	x	x		x				x	x	x							x	x																
Haqdarshak	welfare					x	x	x		x				x	x	x	x						x	x								x	x															
Institute for Transformative Technologies, Tata Power, Rockefeller Foundation	energy					x	x			x			x	x	x	x	x					x	x	x			x					x	x															
Kheyti	agriculture			x				x		x	x		x	x	x	x	x						x	x			(x)					x	x															
Lenddo	financial		x				x											x	x						x				x																			
Mindspark	education		x					x		x	x		x	x	x	x				x				x																									
Mobihealth	health					x	x	x		x	x		x	x	x	x	x					x	x	(x)		x					x	x																
mobile phone providers	technology					x	x			x				x	x	x	x	x	x				x								x																	
mPharma	health					x	x	x		x	x		x	x	x	x	x	x	x				x	x				x																					
Mpost	logistics					x				x			x	x	x	x	x						x																									
Mr Green Africa	recycling					x	x	x		x	x		x	x	x	x		x	x		x			x																								
Muskaan Dreams	education					x	x			x	x		x	x	x	x	x						x	x				x				x	x		(x)													
Musoni	financial					x		x		x	x		x	x	x	x	x						x	x							x	x			x													
Project Circleg	health				x	x			x	x	x		x	x	x	x	x						x	x				x				x	x															
Shortlist	employment			x				x		x	x		x	x	x	x	x						x	x				x				x	x															
Tai	education		x																																														
Yoco	financial					x	x			x	x		x	x	x	x	x						x	x				x				x	x															
Zenvus	agriculture			x		x	x	x		x	x		x	x	x	x	x	x	x		x		x	x							x	x															

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