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Harnessing rapid technological change for inclusive and sustainable development

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I. Introduction

At its twentieth-second session, held in Geneva, Switzerland in May 2019, the Commission on Science and Technology for Development (CSTD) selected "Harnessing rapid technological change for inclusive and sustainable development" as one of its two priority themes for the 2019–2020 intersessional period.

To contribute to a better understanding of this theme and to assist the Commission in its deliberations at its twenty-third session, the Commission secretariat has prepared this issues paper based on relevant literature and country case studies contributed by Commission members.

This priority theme reflects the continuous interest of the Commission to better understand the impact of rapid technological change on societies, economies and the environment. It follows the discussions on the related priority theme for the twenty-second session of the Commission on "The impact of rapid technological change on sustainable development",[2] as well as the discussions at a High-level Roundtable on the "Impact of rapid technological change on the achievement of the Sustainable Development Goals"[3] during the twenty-first session of the Commission. These discussions were a direct response to the General Assembly resolutions A/RES/72/242 and A/RES/73/17, which requested the Commission to continue to consider the impact of key rapid technological changes on achieving the Sustainable Development Goals (SDGs).

In these previous discussions, the Commission underscored that rapid technological change and frontier technologies bring enormous opportunities to accelerate progress towards the SDGs. At the same time, they also pose new challenges, as they could disrupt labour markets, exacerbate or create new inequalities, and raise ethical questions. Consequently, science, technology and innovation (STI) policy has a role to play in shaping frontier technologies for the future as well as addressing already existing inequalities through accelerating progress in bridging them through innovation.

This issues paper advances that 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 STI policy needs to address going foreward. The analysis explores ways to steer rapid technological change towards improved inclusiveness in terms of income, gender, various age groups, people with special needs or other groups facing specific challenges. To keep the discussion focused, the inequalities considered in this paper are not necessarily linked to all frontier technologies, but mostly to a set of digital frontier technologies such as artificial intelligence (AI), big data, and robotics. In particular, the issues paper focuses on ways to assist the development of appropriate business models that allow inclusive innovation using frontier technologies to be scaled up for inclusive and sustainable development.

The paper is structured as follows. Section II discusses some of the potential channels of the impact of rapid technological change on inequalities and how to mitigate that threat. Section III examines in more detail the role of inclusive and sustainable innovative business models to make the dissemination of frontier technologies more inclusive. Section IV discusses the role of STI Policies in creating an environment for harnessing frontier technologies to ensure that no one is left behind. Section V discusses international collaboration. Section VI presents policy considerations for the Member States, the CSTD, and other relevant stakeholders. Section VII lists questions for discussions

[2] E/CN.16/2019/2.

[33] E/2018/31-E/CN.16/2018/4.

to further the dialogue related to harnessing rapid technological change for inclusive and sustainable development.

II. Technological change and inequalities

People on average are living longer and healthier lives, getting more years of education and having better access to clean water, sanitation and electricity. A global middle class has emerged, fuelled by rapid growth in emerging economies and other populous and relatively poor countries. At the same time, wealth is more concentrated with 26 billionaires owning as much as half the global population;[4] poverty is stubbornly persistent in some pockets with more than half of the world's extreme poor living in sub-Saharan Africa;[5] and disparities in education, health and income opportunities still run deep along the lines of gender, urban/rural location, and country of birth. Global inequality, in terms of gaps between countries' mean incomes, has reduced, but income inequality has increased in most countries.[6] The middle class in many advanced economies have sent strong signs of discontent. People in fragile and war-torn countries have seen no other option than to try to leave. Anywhere, when a new generation has no hope to be better off than the past one, the result is despair and conflict.

Technological change is essential for economic growth and sustainable development, but it can initially widen inequalities. From the users' perspective, recent technological advances could bring huge benefits that touch on all SDGs.[7] However, not everyone gets immediate access to this progress, such as a life-saving treatment, access to clean water, specific knowledge or piece of technology.[8] 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. This 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 could also affect the direction of innovation in ways that could 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 access to new technologies depend on how they generate their income. In this regard, some frontier technologies (for instance, AI, digital platforms, and robotics) can disrupt labour markets significantly. 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 from the users' side the benefits of frontier technologies reach the largest 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 losers' side during the transition have the support to find new livelihood paths with dignity, that innovation on frontier technologies is carried out alongside healthy competition to avoid excessive market concentration, and that less

[4] Oxfam (2019). Public good or private wealth. Oxfam Briefing Paper, January 2019.
[5] For example, see https://www.un.org/sustainabledevelopment/progress-report/ (accessed 18 October 2019).
[6] Milanovic, B., Roemer, J. (2016). Interaction of global and national income inequalities, *Journal of Globalization and Development.* 7(1).
[7] For example, see UNCTAD (2018). Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development. UNCTAD/TIR/2018.
[8] As noted by the economist and Nobel Laureate Angus Deaton, "Inequality is often the consequence of progress", Deaton, A. (2015). *The Great Escape: Health, Wealth, and the Origins of Inequality*.

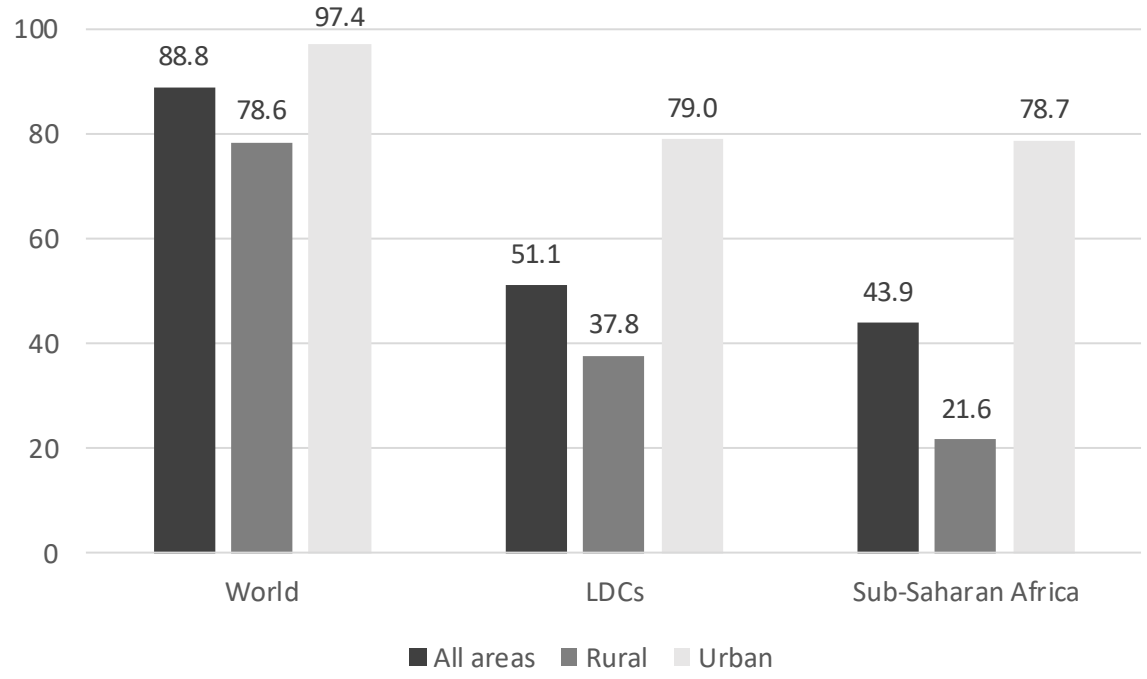
technologically advanced countries have the support of the international community in their aspirations to catch up with more technologically advanced economies.

The following sections further discuss some of the different channels of the impact of technological change on inequalities.

A. Unequal access to new technologies

Rapid technological change could affect inequality through unequal access to products and services that are enabled by new technologies. An important issue for the access to these goods and services is the availability and access to essential technological support infrastructure (for example electricity and the Internet). Unequal access to these support infrastructures is closely associated with geographic disparities in coverage of the infrastructure (e.g. rural and urban, mountainous or remote regions) and their affordability. For example, access to electricity, despite the progress at the global level, remains a luxury to a large share of the population in the least developed countries and countries in Sub-Saharan Africa, particularly in rural areas. In 2017, only 37.8 per cent of the rural population in least developed countries had access to electricity, and only 21.6 per cent in rural areas in Sub-Saharan African countries, as compared with 78.6 per cent of the rural population in the World (Figure 1). In this regard, frontier technologies themselves could provide some solutions to accelerate access to electricity through the use of renewable energy technologies,[9] and could provide an opportunity to leapfrog traditional energy technology solutions. For example, off-grid and mini-grid solutions using solar technology could be the most cost-effective solution to give access to electricity to all households in sub-Saharan Africa by 2030.[10]

Figure 1. The proportion of the population with access to electricity in 2017, by urban/rural (%)



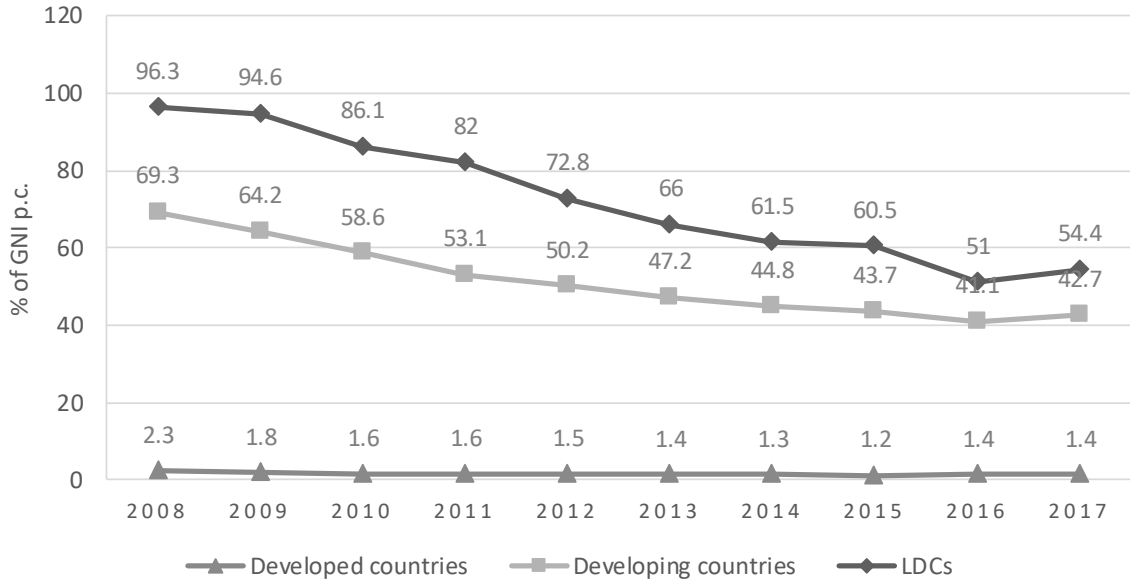
Source: UNCTAD based on data from United Nations Global SDGs Database.

[9] E/CN.16/2018/2.
[10] UNCTAD/PRESS/PB/2018/8.

Access to the 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, businesses are conducted, and governments relate to their citizens. In this connection, it is important to note that, in 2018, 3.9 billion people had access to the Internet. For the first time in history more than half of the world's population were connected to the Internet. At the same time, it also means that another half is still disconnected and, in practice, out of direct reach of the benefits of innovations enabled by digital platforms. Those disconnected are not equally distributed around the world. Less than 20 per cent of people in Europe do not have access to the Internet while over 75 per cent in sub-Saharan Africa and more than 80 per cent of those in the least developed countries lack access.[11]

In addition to issues of poor digital infrastructure, affordability also is a critical element that affects access to new technologies. For example, the price of Internet access in developing and the least developed countries has reduced by up to half since 2008, but it is still high. While the monthly price of fixed-broadband in developed countries is on average 1.4 per cent of per capita GNI, the price in developing countries is around 42.7 per cent of per capita GNI and 54.4 per cent in the least developed countries (Figure 2). A similar pattern is seen in the affordability of mobile Internet, with the price of mobile cellular basket in developed countries being on average 1 per cent of GNI per capita, while in developing countries it is 4.5 per cent and in LDCs, 9.8 per cent.[12]

Figure 2. Monthly price of a fixed-broadband basket, selected groups of countries, as a percentage of GNI per capita



Source: UNCTAD based on data from ICT Price Baskets (IPB). ITUdata.

Notes: ICT Price Basket Rules (from 2018) are available at https://www.itu.int/en/ITU-D/Statistics/Documents/ICT_Prices/ICT%20Price%20Basket%20rules_E.pdf.

Access is also affected by the interplay of personal factors that enable or prevent the use of the frontier technology (e.g. basic literacy, basic digital skills, age and accessibility issues). Social factors

[11] ITU (2018). Measuring the information society report 2018. International Telecommunication Union. Geneva.
[12] ICT Price Baskets (IPB). ITUdata, available from https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx.

that constrain the access of certain groups of people to the goods and services can also perpetuate inequality. For instance, due to social norms, girls and unmarried women in some Indian villages are not allowed to use mobile phones.[13]

This discussion shows that existing inequalities must be addressed head-on and in the first place, prior to other specific measures to avoid the threat of rapid technological change perpetuating or increasing inequalities. Governments and other stakeholders should continue striving to reach universal electrification and to close digital divides. All stakeholders should also continue to fight all forms of social biases and discriminations. Governments should explore ways to increase the coverage of new goods and services that use frontier technologies and address the SDGs to vulnerable and low-income groups, including by providing these goods and services as public services, for example in the case of AI-based solutions in medicine introduced in Latvia (see Box 1).

Box 1. Bridging the treatment gap – AI in cancer diagnosis in Latvia

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

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

Sources: Contribution from the Government of Latvia; Olaku O and Taylor EA (2017). Cancer in the medically underserved population. *Primary Care: Clinics in Office Practice*. 44(1): 87-97; World Health Organization (2018). *Cancer – Fact sheet*. Available at https://www.who.int/news-room/fact-sheets/detail/cancer (accessed on 7 October 2019).

B. Biased design

The way that technology is designed and used can also perpetuate and increase inequalities. For example, the default female voice of AI digital assistants (e.g. Amazon's Alexa, Apple's Siri, and chatbots) could perpetuate gender biases and the stereotype of women in subservient positions. [14] 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;[15] and in fitness trackers that underestimate predominantly female-associated activities such as housework.[16]

Furthermore, AI is only as good as its training data. For example, in 2014, an AI 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 AI 'learned it' based on the historical

[13] For more information, see https://www.independent.co.uk/news/world/asia/girls-and-unmarried-women-in-india-forbidden-from-using-mobile-phones-to-prevent-disturbance-in-a6888911.html

[14] EQUALS (2019). *I'd blush if I could – Closing gender divides in digital skills through education*. UNESCO. Paris.

[15] Tatman R (2016). Google's Speech Recognition Has a Gender Bias. Available at https://makingnoiseandhearingthings.com/2016/07/12/googles-speech-recognition-has-a-gender-bias/ (accessed 7 October 2019).

[16] Nelson MB, Kaminsky LA, Dickin DC and Montoye AH (2016). Validity of Consumer-Based Physical Activity Monitors for Specific Activity Types. *Medicine and Science in Sports and Exercise*. 48(8): 1619–28. https://doi.org/10.1249/MSS.0000000000000933.

recruitment data of the company, which was biased. After identifying the problem, a fix was introduced, but people realized that there were no guarantees that other biases would not be introduced, and the system was abandoned (after three years of biased recruitment).[17] In yet another case, an AI system to assist judges in making better sentencing decisions based on predictions of the likelihood of criminals re-offend was found to be biased against ethnic minorities.[18] Many other cases have been also reported in which the digitalization of welfare services, and the mandatory use of digital channels to access social services, work and pensions, disability and health benefits, although improving efficiency and transparency, also could punish those that do not have digital access and skills. Glitches in these systems can also let people without access to benefits, which in some cases could result in life-or-death situations.[19]

The international community has a role to play in raising the awareness of 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 these products need to build their capacity to identify potential negative effects of their products in the society and establish mechanism to improve their R&D processes to avoid biased design. All stakeholders should pay particular attention to developing mechanisms to ensure that data used for training AI applications are free from biases and discriminations that could be replicated by these applications.

C. Automation of tasks

Some frontier technologies (e.g. AI and robotics) can disrupt labour markets significantly. Some of these technologies are expected to benefit workers performing non-routine tasks, both in manual and cognitive jobs, which can affect both high- and low-paid jobs. A few highly skilled workers in creative jobs and those who own capital, data, models and algorithms will stand to gain. At the same time, workers performing routine tasks are expected to face pressures from ever more capable machines and AI software. The risk is that routine jobs would vanish as they are 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 US and European jobs are at risk of automation in the coming decades as digital technologies increasingly replace humans at work.[20] Others see a modest impact across occupations of an average below 10 per cent.[21]

Not all application of AI and robotics save labour and threaten jobs. When an innovation results in new products and services that fulfil previously unmet needs, it not only increases human wellbeing in general but also tends to create jobs. For example, chatbots and virtual assistants can provide services online and improve users experience in dealing with businesses and governments; services

[17] See https://www.theverge.com/2018/10/10/17958784/ai-recruiting-tool-bias-amazon-report (accessed 7 October 2019).

[18] For more information, see http://harvardmagazine.com/2019/01/artificial-intelligence-limitations (accessed 7 October 2019).

[19] For some examples, see the Guardian's automating poverty series: https://www.theguardian.com/technology/series/automating-poverty (accessed 18 October 2019).

[20] For example, up to 47 per cent of jobs are at risk of being automated in: Frey CB and Osborne M (2016). The future of employment: How susceptible are jobs to computerisation? *Technology Forecasting and Social Change*. 114:254-280; and on average 54 per cent in EU-28 according to: Bowles J (2014). *The computerization of European jobs*. The Bruegel Institute.

[21] For example, across OECD countries the average of jobs that are at risk of being automated is 9 per cent. See Arntz M, Gregory T and Zierahn U (2016). The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing.

that otherwise would not be available anyway given the intense labour-requirements or the vast amount of knowledge needed to provide them (see Box 2). At the same time, jobs are created to give support, maintain and further develop these new services.

Box 2. Chatbots and virtual assistants – Frontier technologies bringing public services closer

Advances in machine learning and artificial intelligence are entering the public sector domain. More public administrations are introducing communication tools which allow citizens to get more personalised answers to their queries than a website might offer. Thereby making access more equal for citizens.

In Mexico, the Ministry of Foreign Affairs is working on introducing a chatbot that will streamline information in a number of domains to ease outreach to Mexicans abroad: general information, passport and consular services, social and financial protection abroad and civil rights such as voting.

Latvia's administration is using virtual assistants to serve customers better. The aim is to develop a unified virtual assistant platform for public administration. At this point different assistants have been introduced. For instance, for the Enterprise Register to interact with customers and the Rural Support Service uses one to check eligibility of recipients of aid based on their criminal record.

Sources: Contributions from the Governments of Latvia and Mexico.

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

Box 3. Helping refugees through learning digital skills to join a globalized job market

EMPACT (formerly known as Tech for Food) is a programme by the WFP to create opportunities for refugees and vulnerable communities to find alternative livelihood opportunities through freelance jobs online. EMPACT is composed of tailored digital training courses that provide hard (e.g. data cleaning, picture tagging) and soft skills to help bridge the gap between poverty and a new career in a globalized job market. Selected participants in the programme also have the opportunity to learn more advanced skills such as coding. The programme also provides mentoring and coaching to help participants to find work opportunities online. In 2018, together with a network of private sector companies, WFP trained more than 2,500 Syrian refugees, displaced or vulnerable Lebanese and Iraqis affected by war and economic crisis. Over 50 per cent of graduates are women. The benefits are improved financial self-reliance, increased social cohesion and less dependence on humanitarian assistance. Nearly one-third of graduates were able to immediately connect to online, freelancing work opportunities and make a monthly average income of US$ 135. The WFP is currently designing and deploying a model to scale up EMPACT. The goal is to reach 20,000 students by the end of 2020; 100,000 people over the next five years, with immediate plans to expand to North and East Africa.

EMPACT has also begun work in the Kakuma refugee camp in Kenya and plans to continue to scale in 2019. Pilots are also planned in Ghana.

Source: Contribution from the World Food Programme.

Frontier technologies could make high-skilled services (e.g. engineering, law, finance, medical) globally tradeable, creating many opportunities for high-skilled workers in developing countries, but also putting white-collar workers in developed and developing countries in direct competition. This process would be enabled by improvements in machine translation (removing the language barrier), in telepresence and augmented reality applications (reducing the distance barrier).[22]

Thus, new jobs will be created too—in various other sectors, but it is too early to decipher the net effect on the labour markets, particularly when considering the impact across countries and through the channels of trade and specialization patterns. Short- and medium-term disruptions with winners and losers are unavoidable, as in any structural economic change. Government and other stakeholders should 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, life-long 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 these technologies (e.g. search engines, cloud computing, AI services) is such that winners take all, leading to market concentration. Innovative firms have higher profits due to temporary monopolistic situations. These Schumpeterian rents – higher 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 exercise their market power further.[23] In addition, process innovation using technologies, such as AI, is expected to replace workers, reducing costs and potentially prices, which could increase market shares and profits. Hence, these increases in market concentration and profits are often a direct consequence of innovation.

Although innovation creates winners and losers among firms, the position of these firms is not static. The relative position of firms changes over time, again driven by innovation. Therefore, innovation promotion can prevent this inequality due to market concentration from being perpetuated. The dissemination of innovations among firms can also promote increasing 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 the examples of successful business models. Some examples of such programmes are the "Made Different: enabling factories of the future" programme in Belgium, the SME Capability Center in Turkey, and the "Digital Technologies" project in the Russian Federation (see Box 4). There is also a role for competition policy to reduce the potential negative effects of excessive market power of leading technology firms on further innovation.

Box 4. Factories for the future

[22] For example, see Baldwin, R. (2019). *The Globotics Upheaval: Globalization, robotics and the future of work*. Weidenfeld & Nicolson. London.

[23] Contribution from the Economic and Social Commission for Asia and the Pacific; ESCAP (2019) Inequality in Asia and the Pacific in the era of the 2030 Agenda for Sustainable Development. ESCAP. Bangkok.

With rapid technological change gaps can develop between the first adopters of technologies in the production process and lagging ones. Several countries are introducing programmes which assist firms in getting to know new production possibilities.

In Belgium, Wallonia's 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 region. The programme aims to raise awareness, diagnose and support towards this change.

Turkey established a first Model Factory, also called the SME Capability Center, 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.

Within the "Digital Economy of the Russian Federation" Program the federal "Digital Technologies" project focuses on end-to-end digital technologies. One key focus of this project is to support domestic research and development by facilitating the knowledge transfer into flagship companies for application and commercialization of the new products.

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

E. Widening the technological gap

While some frontier technologies can create opportunities for the democratization of innovation, they 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 to perpetuate 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 innovative process, in which firms must find ways to produce an existing good or service in a totally different, and many times extremely challenging, social, economic and business environment. Given these difficulties, emulation is usually an incremental process and path-dependent process. [24] Therefore, they need the capacity to absorb and adapt technologies and business models to the receiving country's context.[25] If the capacity and technological gap between firms in developed and developing countries are widened by the former's adoption of frontier technologies, then the emulation by developing country's firms become more challenging.

The technological gap between the frontier-firms and other firms in developed countries is widening too. This gap slows technological diffusion and enables frontier firms to capture bigger market shares

[24] See, for example, Hausmann R and Klinger B (2007). The structure of the product space and the evolution of comparative advantage. CDI Working Paper No.146. Harvard University, Center for International Development; and Arthur B (2009). *The nature of technology: what it is and how it evolves*. Penguin. London.

[25] See, for example, Abramovitz MA (1986). Catching up, forging ahead and falling behind. *Journal of Economic History.* 46:385-406.; Lall S (1992). Technological capabilities and industrialisation. *World Development*. 20(2):165–186.

and profits. Thus, the technological gap 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 would become irrelevant with ICTs. Therefore, innovation policy which always had a geographical dimension (e.g. clusters and parks), leading to increased concentration of innovative firms and workers with the skills they demand, may need to reconsider how to address this issue to spread the benefits of innovation more evenly over the 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 transformations. Some examples are Brazil (liquid biofuels), China (photovoltaic and solar thermal heating technologies),[26] and India, Mexico and the United Arab Emirates with their AI strategies.[27]

The discussion above illustrates the speculative nature of the debate on the impact of rapid technological change on the inequality across countries. Existing theories and models point to possible channels of impact, but the actual effect depends on specific sectors affected, the capacities of countries, and 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 could capture the effects of process and product innovations using labour-saving frontier technologies in employment and growth of developing and developing countries, as well as in the inequality across countries.

III. Inclusive and sustainable innovative business models

Achieving the Sustainable Development Goals by 2030 requires filling a funding gap of 2 to 4 trillion US dollars annually.[28] The public sector is essential in delivering on the Goals, but cannot finance the demands across all relevant sectors. Consequently, private sector contributions are important.[29] Business models that are oriented towards more inclusive and sustainable, both economically and environmentally, paths 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.[30] Innovation, in essence, consists of generation, transposition or adoption of business ideas (not only technical ideas). Knowledge about a new technology does not guarantee that it will be economically viable in a new setting. The technological knowledge from the science and technology sector needs to

[26] International Renewable Energy Agency (2016). The Power to Change: Solar and Wind Cost Reduction Potential to 2025. International Renewable Energy Agency. Available at www.irena.org/publications/2016/Jun/The-Power-to-Change-Solar-and-Wind-Cost-Reduction-Potential-to-2025 (accessed 7 October 2019).

[27] For a list of recent strategies, see: https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd (accessed 7 October 2019).

[28] United Nations Association-UK (2019). Filling the finance gap. Available at https://www.sustainablegoals.org.uk/filling-the-finance-gap/ (accessed 17 October 2019).

[29] UNCTAD (2017). New innovatioin approaches to support the implementation of the Sustainable Development Goals. Current Studies on Science, Technology and Innovation. UNCTAD/DTL/STICT/2017/4. UNCTAD. Geneva.

[30] Remane G, Hanelt A, Tesch JF and Kolbe LM (2017). The Business Model Pattern Database – A Tool for Systematic Business Model Innovation. *International Journal of Innovation Management*. 21(1).

be turned into practical application. The business sector is one point where this translation from theory into practice can occur.[31, 32]

From the consumer perspective, inclusive and sustainable business models could additionally reduce the poverty premium that the poor face, i.e. paying (relatively) higher prices for goods and services than middle-income households would. This price difference can arise where there are local monopolies, weak distribution networks, and strong traditional intermediaries. These factors make every-day goods such as credit, water, phone calls and medication cost more to the poor. Demand-side factors can also play a role. For instance, low-income consumers might choose services and products at a relatively higher cost because the payment method seems to allow for more cost control.[33] The poverty premium might not be as large as it once was,[34] in part because of new technological developments which have made access to goods and services cheaper for everyone. In part because consumers have become more connected and informed, thus they are more aware of pricing and quality of products and services.

From the business perspective, targeting the poor makes economic sense. The global middle class has grown sizably recently, but its purchasing power is still below that of the middle class in industrialised countries.[35] Additionally, 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 might not be large individually, but in aggregate they represent a large market force.

As a result, a growing number of businesses now aims 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 started to spread in the early 2000s.[36] Today, two decades later, the idea of "merging profit with purpose"[37] is no longer a matter for debate in the business community. Much rather it is a question of how business can deliver profitably, while contributing to a better life for a broader number of people through their products and services.

A new wave of business ideas has emerged that are considered promising investments. According to market data from one venture fund, tech start-ups in Africa raised more than 1 billion US dollars in equity funding in 2018.[38] This represents a growth of 108 per cent year-on-year.[39] Nine countries received funding of more than 10 million US dollars: Kenya, Nigeria, South Africa, Tanzania, Egypt,

[31] UNCTAD (2013). Transfer of technology and knowledge-sharing for development. Current Studies on Science, Technology and Innovation. UNCTAD/DTL/STICT/2013/8. UNCTAD. Geneva.

[32] Additional actors that can be involved in innovation for sustainable development are the research sector, organisations that support knowledge management and transfer, citizens and civil society and of course the public sector. See UNCTAD (2019). A Framework for Science, Technology and Innovation Policy Reviews – Harnessing innovation for sustainable development. UNCTAD. Geneva.

[33] Prahalad C (2006). *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing; and Davies S, Finney A and Hartfree Y (2016). The Poverty Premium - When low-income households pay more for essential goods and services. University of Bristol.

[34] *Harvard Business Review* (2013). The Problem with the "Poverty Premium." 1 April.

[35] Milanovic B (2016). *Global Inequality: A New Approach for the Age of Globalization*. Harvard University Press. Cambridge, MA.

[36] Prahalad C and Hart SL (2002). The Fortune at the Bottom of the Pyramid. *strategy+business*. (26); and Prahalad C (2006). *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing.

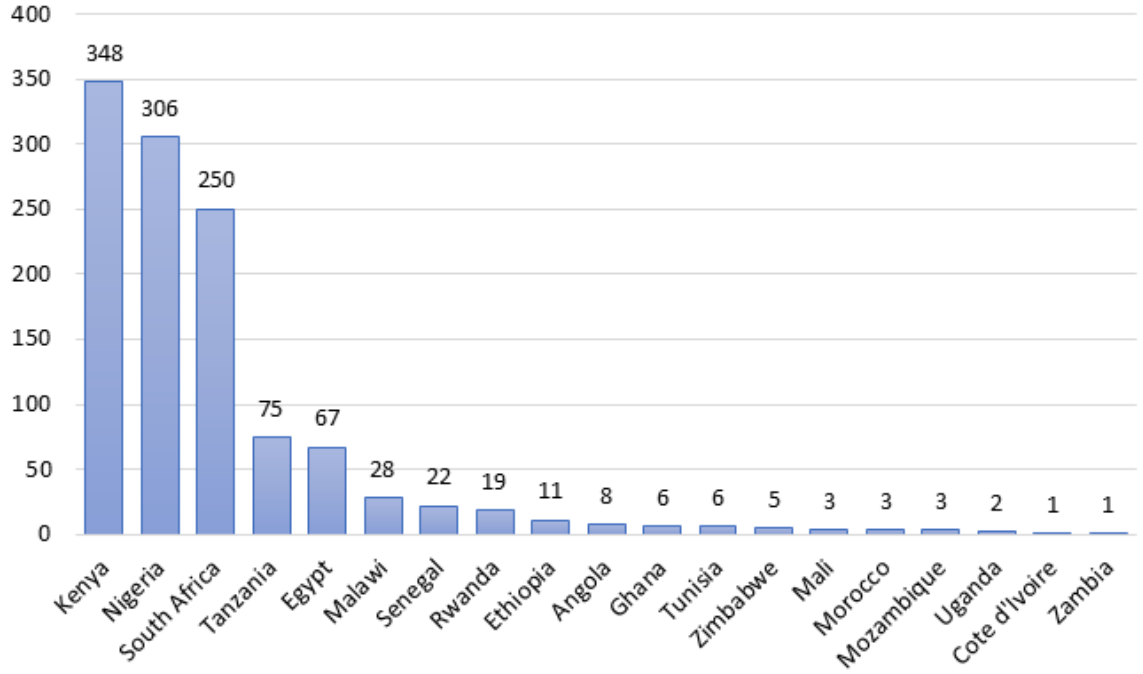
[37] Prahalad D (2019). The new fortune at the bottom of the pyramid. *strategy+business*. (94).

[38] Total foreign direct investment to African countries in the same year amounted to 46 billion US dollars (see UNCTAD (2019). World Investment Report 2019 – Special Economic Zones. UNCTAD/WIR/2019). This tech start-up funding consequently amounts to 2.5 per cent of overall capital inflows.

[39] Partech Partners (2019). Partech Africa Fund Report 2018.

Malawi, Senegal, Rwanda and Ethiopia (see Figure 3). Some of the largest recipients have business models which align with the SDGs, especially in the domain of financial inclusion, such as Tala from Kenya which offers loans via a mobile app using non-traditional loan scoring.[40] Other vital areas for inclusive and sustainable development and achieving the SDGs still need to generate promising solutions. For example, education and health received only 2.7 and 1.5 per cent of all equity funding respectively, whereas fintech dominates (see Figure 4).

Figure 3. Equity funding to start-ups in Africa, selected countries (in million US$)



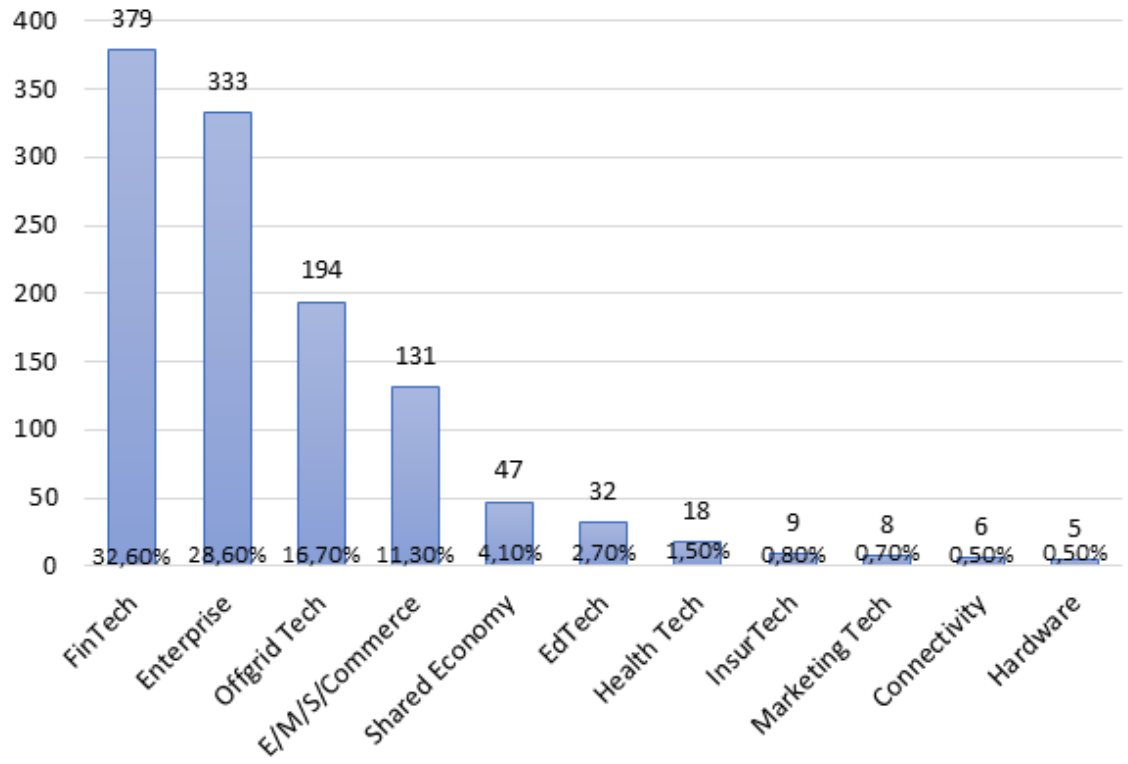
Source: Partech Partners, Partech Africa Fund Report 2018.

Inclusive business models using frontier technologies are not restricted to those "for-profit", although these tend to be economically more sustainable. Delivering on inclusive and sustainable development through businesses lowers the financial burden on governments of 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 persist 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 introduced financial tools for the previously unbanked).

The next sections discuss some of the elements and characteristics of inclusive and sustainable business models of innovative solutions using frontier technologies, the challenges of reaching the extremely poor and key issues for the development of these business models.

Figure 4. Total funding to start-ups in Africa per sector in 2018 (in million US$ and percent of total)

[40] Tala Kenya (2019). Tala Kenya. Available at https://tala.co.ke/about/ (accessed 27 September 2019).



Source: Partech Partners, Partech Africa Fund Report 2018.

A. Elements and characteristics of inclusive and sustainable business models

As in any business endeavour, supply and demand-side aspects matter for businesses to contribute to inclusiveness and sustainability. Businesses have to find ways to deliver low-price quality products to low-income individuals, which are a large market in aggregate but not necessarily individually.

1. Supply-side

On the supply side, critical elements of inclusive and sustainable business models are related to pricing, payments 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 it is another party that bears the costs, such as the business model of search engines where users benefit from the service while advertisers cover the monetary costs – users 'pay' indirectly with their data that platforms monetise. Another element is how users engage with the business for the value creation, whether in a standard way or in a more flexible approach in which the business customize products to the special needs of various groups of users. The latter would be more inclusive but could be more costly and thus less affordable. An inclusive and sustainable business model is not just about the sale of a product. The maintenance of goods and services in often challenging environments, where technical skills, parts, and related services are often unavailable, is another essential part to consider for an inclusive business model. Another critical factor is monetizing the new business model through the pricing system, and the timing of money collection (i.e. before, during or after the service).

Inclusive business models usually have to rethink the entire value chain and the value proposition of products and services, leading to new products for the low-income market. Traditional business models of business-to-consumer, that target richer consumers, need to be comprehensively revised. Existing products cannot simply be fine-tuned and sold more cheaply. This requires changing the cost structure, most commonly by moving from larger margins to smaller ones at higher sales volume, to

reduce the prices of inputs.[41] Changing the cost structure in this manner is not unique to inclusive business models. However it requires a particular effort ot maximise efficiency gains to be affordable for the poor. The launch of the Indian mobile phone provider Reliance Jio did this, disrupting the mobile phone market of high margins to offer low-cost phones and cheap mobile data.[42] The 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 model 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 where the low-income market is small in a relatively small country.[43]

In reshaping business models for inclusiveness, frontier and digital technologies play an important role. Technologies can improve efficiency (e.g. telemedicine using video calls improves long-distance diagnostics) and they contribute to new business models (e.g. peer-to-peer ridesharing through apps).[44] Business models that provide app-based solutions have to take into consideration innovation and business models in the realm of mobile applications. As a result, these solutions tend to follow the business model of mobile apps and provide free services to users in exchange for the right to own and use the data generated or shared by the users during the transactions. These business models can consequently create ethical issues related to the use and privacy of data.[45] Some disruptive business models are rather reactive. 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 of disruptive business models that focus on the customer and in new ways of creating value for them.[46]

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. So inclusive business models need to cater to these two factors.

Affordability

The total cost of ownership of a product matter. In its most basic form, this implies the purchasing cost as well as 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.[47] The product has to last longer or be more effective at a lower price. Hence, it has to be better quality. For instance, in conditions with irregular electricity supply, a battery charger of a mobile phone needs to last more than a day. In another example, the business model of some off-grid solar powered energy solutions includes constant monitoring to address maintenance and repair. Once a unit nears the end of its life cycle, a new one is automatically shipped to the user to prevent an interruption of service. This business model demonstrates a more holistic approach to

[41] Prahalad C and Hart SL (2002). The Fortune at the Bottom of the Pyramid. *strategy+business*. (26).
[42] Sender H (2019). India Tech: How Reliance's low-cost mobile service is transforming society. *Nikkei Asian Review.* 27 March.
[43] Prahalad C (2006). *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing.
[44] Baden-Fuller C and Haefliger S (2013). Business Models and Technological Innovation. Long Range Planning. Managing Business Models for Innovation, *Strategic Change and Value Creatio*n. 46(6):419–426.
[45] UNCTAD (2019c). Digital Economy Report 2019. UNCTAD/DER/2019.
[46] Schiavi GS, Behr A (2018). Emerging technologies and new business models: a review on disruptive business models. *Innovation & Management Review.* 15(4): 338-355. https://doi.org/10.1108/INMR-03-2018-0013.
[47] Prahalad C (2006). *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing.

keeping the customers connected beyond their first purchase and ensuring affordability of the product.[48]

Recent business models take into account that the initial cost cannot be prohibitive. As a result, new buying schemes are being developed, such as lease-to-own. For instance, Fenix and Zola Electric, two off-grid solar powered energy solution offer this possibility.[49] To date, these two firms have provided more than 3 million individuals with electricity in seven African countries. Customers set up the utility-in-a-box system and regularly top it up with mobile money to use the system, buy complementary low-energy electronics and repay their loan. Once the loan is paid off, the system unlocks permanently.

Other business models address the fact that a missing credit score can be an important barrier to accessing credit. That is why some companies, such as Fenix, are harnessing their customer data to create a credit score from non-traditional data. Fenix targets its product at previously unbanked customers. Their repayment record is transformed into a credit score, which gives access to additional products, such as TVs, radios or satellite dishes, but also loans for school fees and insurance. In this way, this business model is targeted toward SDG 7 – affordable and clean energy – but can have knock-on effects in terms of employment and education outcomes. Especially, women and girls benefit from the switch from fossil fuels to solar energy as they spend most of the time indoors.[50] Other firms aim to do the same on a larger scale. For example, using a machine learning algorithm, Lenddo designed propensity-to-pay scores based on customers' mobile phone use patterns and their social network behaviour.[51]

Apart from lease-to-buy schemes, microfinance has expanded with mobile technology and can support affordability. For example, Musoni was established in 2009 in Kenya as the first microfinance institution (MFI) relying entirely on mobile money. Through efficiency gains of being data-driven and cashless, the MFI offers affordable loans to low-income and unbanked populations, of which nearly half are from rural regions and 63 per cent are women.[52] Unbanked populations are not only a concern in developing countries. In the United States of America, a company, Capway, is planning to provide a solution for the unbanked through an app-based bank account without any fees and through app-based personal finance training.[53] However, determining how to make a profit in this model appears to still be open.

Access

Access to points of sales or delivery channels is an important demand-side factor. Business models have to consider that accessing sales points is often not easy in underserved areas in developing countries, as reliable public transport might not exist, and privately-owned vehicles are limited.[54]

[48] Contribution to the forthcoming UNCTAD, Science, Technology and Innovation Policy Review on Uganda. For more information, see Fenix International (2019). Fenix International. Available at https://www.fenixintl.com/; and Zola Electric (2019). ZOLA Electric. Available at https://zolaelectric.com/ (accessed 27 September 2019).

[49] Ibid (Fenix, Zola Electric).

[50] UNCTAD (2019a). The Role of Science, Technology and Innovation in Promoting Renewable Energy by 2030. Current Studies on Science, Technology and Innovation. UNCTAD/DTL/STICT/2019/2. UNCTAD. Geneva. (accessed 28 September 2019).

[51] Lenddo (2019). Lenddo - Leveraging Technology Solutions in Credit and Verification. Available at https://lenddo.com/ (accessed 27 September 2019).

[52] Musoni Microfinance (2019). Available at https://musoni.co.ke/company#content-vision (accessed 27 September 2019).

[53] CapWay (2019). CapWay | Creating Financial Opportunities for Everyone. Available at http://capway.co (accessed 27 September 2019).

[54] Prahalad C (2006). *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing.

Delivery channels are a form to provide access, but, by 2012, 4 billion people were still without a registered address.[55] Apart from the direct commercial impact on not being able to use e-commerce, in many cases it also implies a lack of legal identity as a registered address is the prerequisite.[56] However, there are new solutions to, at least, obtaining a legal address. MPost is a service in Kenya which allows mobile phone numbers to be registered as addresses.[57] The service registers a convenient post office for each account and mail can be picked up from there or delivery can be arranged.

Additionally, inclusive business models have to account for time-poverty, as an important access barrier. Opening hours need to match the customers' schedule. If they work as day-labourers, they cannot miss large chunks of the working day to shop or run errands. Hence, time saved is critical to low-income groups. Digital technologies offer options that can ease time poverty. An early tool was India's eSeva, an online service that aggregates government information and services in one place. It was launched in 2001 and includes e-government services such as passport application forms and payment of utility bills, provided in e-centers with support staff.[58] In this way, eSeva provides a one-stop-shop. However, there are also government services that people might not be aware of, nor that they could be eligible for them. This awareness gap can be bridged by easing access to information through modern technologies. Haqdarshak is an Indian tech platform that connects people with welfare schemes which they are eligible for. Eligibility is established through an adaptive questionnaire. Once this is completed, customers can book a meeting with a trained representative of the platform to complete the welfare scheme applications against a small fee. The platform is specifically targeted towards the impact on SDGs 1, 3, 4, 5, 6 and 9. To date, approximately 220,000 people have received benefits through applications processed by the platform.[59]

Furthermore, digital platforms that provide access to expertise play an important role in business models that address sustainability and inclusiveness. Covered sectors are, for instance, agriculture, education, employment, and health (see Box 5).

Box 5. Digital platform increasing access to expertise

Mobile-based advisory services are increasingly supplementing agricultural solutions for small-hold farmers across the world. In India, Kheyti is rolling out a service which bundles a modular greenhouse and high-quality inputs with mobile-based training and advice.[60] The firm Farmbetter is building a mobile phone app for small-hold farmers in Asia and Africa that gives tailor-made farming advice based on a georeferenced database, a resilience survey for the household, and individual farming preferences which then lead to specific recommendations.[61] In sub-Saharan Africa, Zenvus goes one step further by combining robust smart sensors with real-time analysis in the cloud, forming an

[55] Universal Postal Union (2012). Addressing the world - An address for everyone. Universal Postal Union. Berne.
[56] Gelb AH and Diofasi Metz A (2018). *Identification Revolution: Can Digital ID Be Harnessed for Development?*. Center for Global Development. Washington D.C.
[57] MPost (2019). MPost - An Address for Everyone. Available at https://mpost.co.ke/mpost/ (accessed 27 September 2019).
[58] eSeva (2018). IndiaFilings - Learning Centre. Available at https://www.indiafilings.com/learn/eseva/ (accessed 27 September 2019).
[59] Haqdarshak - Every Citizen Matters (2019). Available at https://haqdarshak.com/home (accessed 27 September 2019).
[60] Kheyti (2019). Kheyti – Small Farmer | Smart Farmer. Available at http://kheyti.com/ (accessed 27 September 2019).
[61] For more information, see https://farmbetter.io (accessed 28 September 2019).

Internet-of-Things environment that advises on farming techniques, uses the data for insurance purposes, and connects to markets.[62]

In education, platforms benefit from recent advances in AI, which allow for personalized learning and access to knowledge. These platforms can be used privately but are also used to support public schools with teacher shortages or to ensure teaching quality.[63]

To achieve SDG 8, decent work and economic growth, new digital solutions such as Shotlist match job seekers in India and Kenya with jobs based on their capabilities, not their credentials. Skills and strengths get assessed online to allow people to qualify even if their CV is non-standard. This is complemented with specific advice from recruitment advisors.[64] Research shows that application processes racially discriminate.[65] The digital service Bloc developed tools that are designed for minority students to turn their experiences into marketable CVs and provide them with feedback on their application material.[66]

Finally, digital platforms allow access to health and medical services, even in remote, medically underserved regions. Two new platforms provide services that are more comprehensive than just a call with a doctor. Babyl in Rwanda provides telemedicine with a call center of medically trained staff. Payment, prescriptions and referrals are done using SMS. Additionally, partner facilities receive short patient information from the call center to allow for smoother handling of cases.[67] Mobihealth from Nigeria offers subscription plans which connect patients with doctors (both local ones and from abroad) as well as paying for medicine and referral visits.[68]

Source: UNCTAD.

B. Patterns of inclusive and sustainable business models

This Issues Paper classifies 24 business models along 12 dimensions to identify the characteristics of sustainable and inclusive innovative business models (See Annex 1 for the list of business models). Each firm has an individual pattern. Business model patterns describe the building blocks that a firm combines to deliver on innovation and to provide value.[69] The multidimensional matrix in Table 1**Error! Reference source not found.** presents the dimensions and different characteristics per

[62] Zenvus (2019). Zenvus – Intelligent solutions for farms and gardens. Available at https://www.zenvus.com/ (accessed 28 September 2019).

[63] For example, see Educational Initiatives (2019). Mindspark Math | Educational Initiatives. Available at https://www.ei-india.com/index.php/mindspark-maths; Muskaan Dreams (2019). Muskaan Dreams - Transforming rural schools into digital learning space. Available at http://muskaandreams.org/; and TAI (2019). TAI - World's Most Powerful K-12 Learning Technology. Built for Extreme Academic Success in School & beyond. Available at https://www.tai.school (accessed 28 September 2019).

[64] Shortlist (2019). Shortlist: Your Career Starts Here - Job Opportunities with Top Employers. Available at https://shortlist.net/ (accessed 28 September 2019).

[65] For example, see Bertrand M and Mullainathan S (2004). Are Emily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination. *American Economic Review*. 94(4):991–1013; and Quillian L, Pager D, Hexel O and Midtbøen AH (2017). Meta-analysis of field experiments shows no change in racial discrimination in hiring over time. *Proceedings of the National Academy of Sciences*. 114(41):10870–10875.

[66] For more information, see https://www.jointhebloc.com/ (accessed 28 September 2019).

[67] For more information, see Babyl – Rwanda's Digital Healthcare Provider. Available at http://www.babyl.rw/ (accessed 28 September 2019)

[68] For more information, see https://mobihealthinternational.com/ (accessed 28 September 2019).

[69] Remane G, Hanelt A, Tesch JF and Kolbe LM (2017). The Business Model Pattern Database – A Tool for Systematic Business Model Innovation. *International Journal of Innovation Management*. 21(1).

dimension. The overarching dimensions to describe a business model are its degree of digitalization, the value proposition, value delivery, value creation and value capture. Furthermore, the matrix contains the count of how many business models exhibit certain characteristics. The darker a cell's colour, the more frequent a characteristic is across the businesses analysed.

Table 1. Dimensions, characteristics and numbers of business models per characteristic

		Characteristics per dimension: number of patterns per characteristic					
Digital	**Degree of digitization**	Purely digital: 7	Digitally enabled: 16	Not necessarily digital: 1			
Value proposition	**Product type**	Physical: 13	Financial: 15	Human: 16	Intellectual property: 9	Hybrid: 19	
	Differentiation strategy	Quality: 17	Customization: 11	Combination: 19	Access/convenience: 18	Price: 17	Network effects: 6
Value delivery	**Target customers**	Specific new customer segment: 22	Lock-in existing customers: 3	Other companies (B2B): 6			
	Value-delivery process	Brand and marketing: 9	Sales channel: 5	Sales model: 11	Customer relationship: 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 one else involved: 14	
	Value-creation process	Research and design: 16	Supply: 15	Production: 12	Multiple steps: 15		
Value capture	**Revenue model**	Sell: 18	Lend/lease: 5	Intermediate: 8	Advertising: 0		
	Pricing strategy	Premium: 1	Cheap: 14	Dynamic: 4	Non-transparent: 8		
	Profit	For-profit: 20	Not for-profit: 2				
	Direct profit effect	Increase revenue: 9	Reduce cost: 6	Multiple effects: 3	No direct profit impact: 12		

Source: UNCTAD based on Remane et al. (2017). *Note*: N=24, characteristics can be overlapping, so rows do not necessarily sum to 24.

Table 1 shows that two-thirds of the business models analysed are digitally enabled**.** Typically, the businesses combine an app or a web platform with an additional physical or financial component. This is particularly the case for the agricultural sector, were a greenhouse-in-a-box or sensors are

complemented by digital advisory services.[70] Similarly, MFIs like Musoni combine their platform for financial services with human advice into a hybrid product that is digitally enabled.[71]

The business models differentiate themselves by easing access to a new service or good. This indicates that they consider that access is an important hurdle to low-income customers. Consequently, firms that find a new way of providing this access, through online platforms or improved supply chains, can access previously unserved customers. For instance, Yoco provides point-of-sale hardware and management software to shops which previously did their sales and inventory manually.[72]

A prolonged customer relationship is a standout factor of most businesses analysed. Through, for instance, continued advice, upgrading within an electronic product environment or lease-to-own schemes, connections between firm and customers extend beyond the initial sale.[73]

However, closer customer relationships do not imply close customer involvement in the product and service creation process. Customer involvement appears to be more common in cases where the business is a multi-sided platform and one customer side is another business, such as the recruitment platform Shortlist or Lenddo, a firm that creates credit scores.[74] Suppliers, on the other hand, are involved in settings where they provide specific expertise such as medical advice or are the service providers for welfare programmes.[75]

The key characteristics of the businesses for their value creation is introducing an innovation or supplying products, not produced by the firm. Innovation here takes the form of either process innovation or product innovation through the firm's internal research and design (R&D). An example of process innovation is mPharma, which streamlined pharma supply chains in several African countries. By encouraging pharmacies to join a larger network, bulk buying medication and streamlining the inventories, prices were reduced by up to a third and the supply stream was improved.[76] Examples of product innovation through R&D are e-learning platforms that allow for a personalised learning experience through proprietary AI algorithms.[77]

The majority of the business ideas have a clear profit focus, while selling relatively cheaply. This pricing level is supported aiming for large customer bases, such as the mobile phone market, and by making service and product delivery as efficient as possible to increase margins.[78]

Moving beyond describing the characteristics of business models, there are policy implications that arise from them. The dominance of digitally enabled businesses emphasises the need for a functional enabling environment that government can contribute to, namely widely accessible mobile networks, including internet capacity at brandwidth as well as the appropriate legislation, such as data protection and privacy laws.

[70] For more information, see, for instance, Kheyti, https://kheyti.com/ (accessed 27 September 2019) and Zenvos, https://www.zenvus.com/ (accessed 28 September 2019).
[71] See Musoni, https://musoni.co.ke (accessed 28 September 2019).
[72] See Yoco, https://www.yoco.co.za/za/ (accessed 2 October 2019).
[73] For continued advice, see, for instance, FarmBetter, Kheyti, and Mobihealth. Regarding upgrading of electronic products and lending through lease-to-own schemes, Fenix and Zola Electric.
[74] See Shortlist and Lenddo.
[75] See Mobihealth and Haqdarshak.
[76] See mPharma, https://www.mpharma.com/ (accessed 2 October 2019).
[77] For more information, see, for instance, Muskaan Dreams and Tai.
[78] Firms that do this come from different sectors, for instance, Musoni in banking, Yoco, as a point-of-sales system, and various learning platforms.

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 identified a lack of financial resources as a bottleneck to attract more customers. Hence, the firms offer lease-to-own schemes (for instance, the solar panel providers) or front the cost of the merchandise (such as mPharma which provides medication to pharmacies free of charge until the medication is sold). These elements are important to support their business, 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. Additionally, firms need realtiviely easy access to financing that they can pass on to their customers to support their business models.

Finally, as there is a profit motive, there is scope for taxation which the public sector can benefit from. However, the respective bureaucracy should support this through, for instance, easing bureaucratic procedures such as 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. This section presents how 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. Agriculture is one of them. Improved agricultural practices can lead to better yields. Additionally, climate change and environmental degradation make adaptation essential. Mobile advisory services for small-hold farmers, such as FarmBetter, can support resilience of farming practices, which are in tune with the local environment and hence prevent further land degradation and can support recovery. Complementing advice with high-quality inputs, such as the greenhouse-in-a-box Kheyti does, is a more holistic business and farming approach which addresses the goals of poverty alleviation and environmental responsibility simultaneously. Furthermore, frontier technologies can support sustainability through improved observation tools. IoT sensors combined with drone imaging can improve farming practices and curb pest outbreaks through earlier observation and data analytics which were not accessible to individual farmers until recently.

Around 840 million people still have no access to electricity. Furthermore, 2.8 billion people do not have access to clean energy sources for cooking.[79] This has important implications for health, society and the environment. Consequently, alternative forms of energy are vital to achieve the SDGs, in particular Goal 7 for affordable and clean energy. Off-grid solar powered energy solutions, such as Fenix and Zola Electric, contribute to achieving this goal by giving its customers access to solar-solutions, including low-energy electronics.[80]

Going forward, material consumption threatens delivering on sustainable development. Consequently, consumption and production have to become more sustainable. Reducing waste and the circular economy are one aspect of this. Through re-designing the value chain such that technology streamlines it and waste collectors become an important part of the process, Mr. Green Africa

[79] UNCTAD (2019a). The Role of Science, Technology and Innovation in Promoting Renewable Energy by 2030. Current Studies on Science, Technology and Innovation. UNCTAD/DTL/STICT/2019/2. UNCTAD. Geneva.

[80] For more information, see Fenix International (2019). Fenix International. Available at https://www.fenixintl.com/; and Zola Electric (2019). ZOLA Electric. Available at https://zolaelectric.com/ (accessed 27 September 2019).

produces recycled raw material for plactic manufacturers.[81] An alternative use of recycled plastic, and contributing to the cicular economy, would be Project Circleg. The project aims to produce low-cost prothestics from recycled plastic waste that can be made in developing countries.[82] Thereby contributing to both 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 with less than $1.90 a day, the internationally agreed poverty line.[83] Poverty remains an issue despite important strides in poverty reduction in the past 25 years. Over 700 million people remain below the international poverty line, excluded from sufficient resources to access education, health and other basic services.. The families live in precarious conditions, in rural areas or squatter settlements of urban areas, usually without access to electricity, clean water and sanitation, with very few possessions and expending all their meagre 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 old vintage mobile phone, but access to Internet is unaffordable.

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

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

In Armenia, the firm Georisk uses data from multiple sources and machine learning to assess the risks from earthquakes in the country. A particular vulnerability during earthquakes are buildings that cannot withstand the shocks, which makes cities dangerous. Through their process, Georisk can produce detailed risk maps, including information on occupancy rates at day- or night time of buildings, impact on infrastructures such as roads, electricity, gas and water supplies. The resulting maps are supposed to inform urban resilience planning.

Similarly, but with a global focus, oneconcern, a United Nations Office for Disaster Risk Reduction (UNDRR) partner, combines AI with physics 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.

[81] For more information see Mr. Green Africa. Available at https://www.mrgreenafrica.com/ (accessed 18 October 2019).

[82] Project Circleg (2019). Project Circleg – Affordable lower-limb prosthetic system. Available at https://projectcircleg.com/ (accessed 28 September 2019).

[83] United Nations. Ending Poverty. Available at https://www.un.org/en/sections/issues-depth/poverty/ (accessed 17 October 2019).

Although, businesses using frontier technologies and considering affordability and access can improve the life of the extremely poor, market forces alone are not sufficient. First, establishing legal identity, in programmes such as India's Aadhaar, is vital to integrate individuals from the fringe into society.[84] Legal identity increases the chances of escaping poverty by opening access to social programs, services such as mobile phones or public utilities, and to financial services such as loans.

Second, as many of the mentioned business models rely on mobile phones and digital platforms, education is vital. Frontier technologies require sufficient literacy levels to navigate the platforms as well as digital skills to be aware of risks associated with financial or confidential transaction online.[85]

Some businesses have to rethink their model to de-skill tasks for consistent service provision. This increases the potential workforce to perform tasks that ensure consistent supply or service delivery. One example is prosthetics which usually need several fittings and are relatively expensive to produce. For consistent delivery in a developing country setting, fittings need to be accelerated for the poor. They cannot spend days in far-away hospitals testing their new limb. Consequently, the prosthetics have to be made in such a way that fittings require minimal effort and can be done by people that underwent relatively little training.[86]

However, technology has evolved into an indirect system of checks and balances that empowers the poor. Better informed and connected consumers are better protected against the abuse of power (i.e. through poverty premiums). Thus, consumer awareness contributes to reducing vulnerabilities of low-income consumers.

E. Key issues

This section examines some key issues for the development of innovative inclusive and sustainable business models.

The innovator who aims to address the challenges of the poor and most vulnerable, or users with special needs, needs to first understand the situations and challenges that these users face. For innovators to define a problem, they often need to be exposed to it. Which is why most innovators innovate for challenges that are close to home.[87] Hence, the poor themselves can be important innovators, inspired by their experiences. Once a problem has been defined, innovation is a process of trial and error, pursuing possible paths, refining or redefining the challenge to be addressed along the way, and eventually finding a solution that represents a significant improvement over present methods of addressing the challenge. Consequently, for more inclusive innovation, entrepreneurship training needs to reach all parts of society to ensure that innovaters address diverse needs successfully.

Weak financing mechanisms continue to impede the development of innovative products and services. Since many businesses at the bottom of the pyramid require a certain scale to be profitable, initial financing is important. Hence, seeing growing inflows of equity funding is promising, but not sufficient. Specific financing must be found to cover the costs of adjustment and reconfiguration of

[84] Gelb AH and Diofasi Metz A (2018). *Identification Revolution: Can Digital ID Be Harnessed for Development?*. Center for Global Development. Washington D.C.

[85] UNCTAD (2019). Building Digital Competencies to Benefit from Frontier Technologies. Current Studies on Science, Technology and Innovation. UNCTAD/DTL/STICT/2019/3. UNCTAD. Geneva.

[86] Project Circleg (2019). Project Circleg – Affordable lower-limb prosthetic system. Available at https://projectcircleg.com/ (accessed 28 September 2019).

[87] Contributions from Dr. Aliza Inbal, Director, Pears Program for Global Innovation, Jerusalem Institute for Policy Research.

the technology to fit the new technological and economic environment. Furthermore, financing covers the transfer costs of the operational and practical knowledge necessary for the installation and maintenance. The life cycle of a technology-oriented business involves several discrete stages of financing, generally provided by different agents. In the very initial stages, business is often bootstrapped or funded by friends and family. This skews the socio-economic profile of startup founders, in developing and developed countries alike, to those who can afford to do so. The first stage of outside funding generally comes at the prototype development and proof-of-concept phase. The private sector begins to get involved at the seed-finance stage, when prototypes are completed, and beta-testing or pilots are launched. This stage is often known as the "valley of death" for startups even in the densest ecosystems, when funding is scarce and hotly contested. However, for disruptive and inclusive business models this problem is substantially greater. Traditional seed-stage technology investors are generally unwilling to invest in products aimed at markets they do not understand and where selling the company once it has grown is harder, and where the duration to achieve profitability is almost invariably longer than in developed country markets. Conversely, impact investors targeting developing countries are generally unwilling to invest in risky, unproven technologies and business models, preferring to invest in companies employing proven technologies in local applications.[88]

Business solutions cannot solve everything. Governments have a role to play in establishing legal identity, but also in encouraging infrastructure development as well as setting the overall legal framework for businesses to operate in. Businesses that contribute to inclusiveness can have access to sensitive personal information, which needs to have sound legal protection. Some recent business models extend beyond one simple product. As they build on a platform or an environment of products, lock-in needs to be considered. For instance, the electronic goods that only work with a specific solar generator may limit people's choices for follow-up purchases. The latter goes against the idea of encouraging inclusive businesses as a means to offer low-income individuals more freedom to make consumption choices.

IV. The role of STI policies

STI policies create an environment for harnessing frontier technologies to put countries on socially and environmentally sustainable development paths.

In many countries, strategies for the development of frontier technologies have been recently proposed to guide the use, adoption, adaptation and development of these technologies. For example, in Belgium public authorities have developed a federal strategy for digitisation (Digital Belgium) and regional strategies (Industrie 4.0, Digital Wallonia, beDigital.Brussels), mostly comprised of projects involving cross-border cooperation are at regional level, often connected to EU programmes.[89] In 2018, Brazil established the National System for Digital Transformation (SinDigital) and the Brazilian Digital Transformation Strategy (E-Digital), which is an umbrella policy aiming to harmonize and coordinate different governmental initiatives on digital issues within a coherent framework and proposes strategic actions under the perspective of the Sustainable Development Goals (SDG) of the 2030 Agenda.[90] In the Russian Federation, the national program "Digital Economy of the Russian Federation" aims at economic development based on the application of information and telecommunication technologies through demand support, support for the Russian hi-tech companies and improved competitiveness of domestic digital products, including at the international

[88] Ibid (Dr. Aliza Inbal).
[89] Contribution from the Government of Belgium.
[90] Contribution from the Government of Brazil.

level.[91] In Turkey, the "Digital Turkey" Roadmap is a comprehensive strategy which covers the human capital, technological capacity, infrastructure, suppliers, consumers and governance.[92]

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" Roadmap strategy aims not to leave anyone behind through training digital technology users in Continuous Education Centres and thematical technical colleges, increasing digital technology developing programs in universities, improving digital literacy of teachers at every level, supporting doctorate degree in digital technologies, supporting to match digital competent human capital with industry, improving awareness of digital transformation, and improving collaboration between digital transformation stakeholders.[93]

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

Box 7. Shaping the workforce of the future

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

In 2015, Riga Technical University established the Engineering High School. It is Latvia's first general secondary education institution linked to a university and closely cooperates with the private sector. The school offers a general education track in mathematics, science and technologies. During holidays the school offers internships at cooperation partner firms. The students can attend certain university courses, work in laboratories and leading researchers give guest lectures. Overall, the students train advanced research skills which prepare them for science tertiary education degrees and research careers.

In Belgium, Technopolis, a science centre funded by the Flemish Government, aims to attract more young people into sciences through increasing enrolment, graduation and advancement. One of its programmes, the STEM-academy, tries to address the skills shortage of scientific profiles through encouraging science interest. It is a network of STEM-related extracurricular activities for young people to make STEM fields and these 21st-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, Germany, France, Luxembourg and the United Kingdom of Great Britain and Northern Ireland supports partner countries in shaping their VET systems to make them relevant for 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 triangular need for information.

To address the skill mismatch between higher education and the private sector, the Scientific and Technological Research Council of Turkey (TÜBİTAK) launched the 2244 – Industry Doctorate Program 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 TÜBİTAK provides three years of employment support following graduation.

[91] Contribution from the Government of the Russian Federation.
[92] Contribution from the Government of Turkey.
[93] Contribution from the Government of Turkey.

America's Strategy for STEM education aims to prepare the workforce of the future through building strong STEM literacy, 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 program to help low-income and unemployed people to improve their skills and find employment. The SPARK tech program is a summer program for DC school children and Girls Who Code encourages girls to learn programming and pursue careers in the field.

Similarly, Turkey's Ministry of Industry and Technology supports Try It & Do It Workshops which bring middle and high school students in contact with coding, artificial intelligence and robotics to stimulate the youths' interest in technology relevant to the industry.

The Lebanese private initiative "All Girls Code" offers a tech immersion programme for girls where they learn the basics of web development and in a hackathon develop ideas for apps, often with a social purpose. The programme which aims to raise girls' interest in STEM fields is then followed up by mentoring, scholarship and career opportunities.

The United Arab Emirates Government's One Million Arab Coders Initiative is an e-learning platform for digital skills to prepare the labour force for the skills of the future

Sources: Contributions from the Governments of Belgium, Latvia, Turkey and the United States of America and the Economic and Social Commission of Western Asia.

Box 8. Women, digital skills and entrepreneurship

Brazil's government launched the Digital Entrepreneurs Project in March 2019. This project 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 of America invests in several programs around the world to encourage women entrepreneurs. The Women Entrepreneurship Finance Initiative Facility aims to increase funding and investment in women's businesses, by also directing private sector investment towards them. This initiative is complemented with technical assistance such as skill training. Similarly, the Overseas Private Investment Corporation (OPIC) has a program which in 2018 initially committed 1 billion US-dollars in 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 being one pillar of the initiative.

Sources: Contributions from the Governments of Brazil and the United States of America.

Technological foresight and evaluation instruments are used to better understand the technological paths and potential social, economic and environmental impacts. For example, one of the strategic actions in the E-Digital strategy of Brazil is to evaluate the potential economic and social impact of disruptive digital technologies and to propose policies that mitigate their negative effects and maximize positive results.[94]

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 Made Different, cluster policies

[94] Contribution from the Government of Brazil.

including the network of innovation clusters and innovative business networks, the living lab programme, and the Digital Health Valley.[95]

Given that technology-based products and services should be affordable to low-income customers and accessible to the larger population, STI policy should target reducing the cost of critical and vital technology-based services. For example, Russian Federation has started pilots of domestically-produced solutions based on end-to-end digital technologies into priority sectors such as healthcare systems, paramedic and obstetrical stations, secondary schools, fire stations, fire posts and police stations, as well as government authorities and local self-government bodies to the Internet.[96]

Since STI activities in some areas have spillover effects which benefit the whole society, STI policy could guide innovation using frontier technologies towards increasing social welfare. For example, in Iran, the Government has considered the balance between benefits and potential negative externalities of the new technologies, through, for instance, building advocacy coalition in favour of innovation and sustainable development in the transportation sector (see Box 9).

Box 9. The regulatory case of Iranian Transportation Network Companies (TNCs)

Policymakers should understand the pros and cons of new technologies. In Iran, the vice presidency for science and technology (VPST) of Iran supports local digital platforms because they provide smart and low-cost services to society. But VPST also considers negative aspects. For example, the impact of these platforms on traffic, or the rights of drivers and the quality of jobs created and promoted by the platforms, i.e. companies that do not classify their drivers as employees. Additionally, the case of competition and trust within this industry are policy concerns. The VPST and other regulatory bodies try to mitigate the negative impacts on society. A unique aspect of this process is the close collaboration of VPST and TNCs to develop an innovation ecosystem and to use the capacity and market of TNCs to shape a green transportation and electronic vehicles industry in Iran. In this case TNCs provide incentives for the riders who use e-vehicles.

Source: Contribution from the Government of Iran.

STI policies for reducing inequalities should focus on strategies and mechanisms that create the enabling environment for innovative approaches such as pro-poor, inclusive, below-the-radar, frugal, bottom-of-the-pyramid, grassroots, and market-oriented and social innovation.

To facilitate the development of appropriate business models for scaling up inclusive innovation using frontier technologies to address the SDGs, STI policy should provide incentives to attract private finance to innovative and inclusive business using frontier technologies through matching funds, risk mitigation and other forms of support for private sector investments. Blended finance, that is, finance that combines two or more modalities of grants, loans and equity investments, often with a mix of public, private and development bank and donor financing has become common in the technology for development impact space, particularly at the levels of seed finance and above.[97]

Policies should also foster engagement of academia and civil society organizations with the private sector to facilitate upscaling of solutions. The STI policy should give due consideration to science parks, incubators (in more technologically advanced countries), accelerators, innovation labs, and marketplaces to incubate innovative ideas and foster innovation clusters, and to facilitate experimentation and faster technology diffusion. For example, the Brazilian Government, in

[95] Contribution from the Government of Belgium.
[96] Contribution from the Government of the Russian Federation.
[97] Contribution from Dr. Aliza Inbal.

partnership with private institutions, has collected expertise from hundreds of industrial innovation specialists in the publication "Perspectives on advanced manufacture by Brazilian experts". The publication highlights the importance of new Open Laboratories, dedicated to developing digital industry technologies, which consider the combination of such technologies generates unprecedented opportunities for competitive manufacturing in Brazil.[98]

At the same time, STI policy should promote the scaling up and dissemination of successful innovations that emerge from these innovation hubs, to reduce the inequality created by the geographic concentration of technological capabilities.

V. International collaboration

Rapid technological change impacts all countries and segments of societies, hence international collaboration is critical to ensure inclusive and sustainable outcomes. This section summarises some of the initiatives that the Member States, the United Nations System and the international community at large have taken to maximise the benefits from rapid technological change and to mitigate its risk.

A. Research cooperation and science-policy interface

Public foundational research remains vital to ensure that emerging technologies are developed with inclusiveness and sustainability in mind. For instance, the European Union's Horizon 2020 program has two initiatives that do so.[99] The EIC Pathfinder Pilot offers grants to radically new technologies to research consortia from at least three different European Union member states and associated countries. Call topics include, for example, artificial intelligence and zero-emission energy generation.[100] Responsible Research and Innovation (RRI) in Horizon 2020 implies that the research process and outcomes should be aligned with society's needs and values and to anticipate its consequences.[101] Hence, the initiative aims to make innovation more inclusive.

The Government of Japan combines ODA with international joint research ventures to promote STI for SDGs. With programmes such as Cross-Ministerial Strategic Innovation Promotion Program (SIP) and the Science and Technology Research Partnership for Sustainable Development (SATREPS), Japan translates research results into social implementation in developing countries.[102] The latter programme additionally aims to enhance research capacity in developing countries. Since its launch in 2008, the programme has started 145 projects in 51 countries.[103]

In Belgium, VITO, the Flemish Institute for Technologic Research, has designed the Global Conferences on Science, Technology, and Innovation (G-STIC)[104] to bridge the gap between cutting-edge technological development and international policy-making. It also provides informal support to United Nations system-wide Technology Facilitation Mechanisms for the worldwide implementation

[98] Contribution from the Government of Brazil.
[99] Contribution from the Government of Brazil.
[100] European Commission (2019). Enhanced EIC pilot. Available at https://ec.europa.eu/research/eic/index.cfm?pg=funding (accessed 7 October 2019).
[101] European Commission (2019). Responsible Research and Innovation – Horizon 2020. Available at https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation (accessed 7 October 2019).
[102] Contribution from the Government of Japan.
[103] Japan Science and Technology Agency (2019). SATREPS. Available at https://www.jst.go.jp/global/english/about.html (accessed on 7 October 2019).
[104] For more information, see https://2019.gstic.org/ (accessed 18 October 2019).

of the SDGs and the transition to less carbon- and resource-intensive, more resilient, economic 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 for harnessing frontier technologies for sustainable development. In this regard, governments, practitioners and the private sector have held extensive discussions on this topic at the Commission on Science and Technology for Development,[105] the Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals (STI Forum),[106] and the AI for Good Summit.[107] Through these discussions, governments can better understand the potential of new technologies in tackling societal challenges, the institutional changes needed to facilitate innovation in these areas, and the international cooperation mechanisms that could be put in place to support these initiatives.

Several United Nations agencies have supported Member States in strengthening their capacities to develop and implement inclusive STI policies, such as UNCTAD's STI policy reviews (STIP Reviews) and UNESCO's STEM and Gender Advancement (SAGA) and Global Observatory on STI policy instruments (GO-SPIN) (see Box 10). The United Nations also support member countries with demonstrations programmes that disseminate best practices in use of frontier technologies for inclusive and sustainable development, such as UNIDO's Global Eco-Industrial Parks Programme (GEIPP) (see Box 11), as well as to foster innovation in addressing specific SDGs, such as FAO's youth entrepreneurship and innovation network on agricultural innovation (see Box 12**Error! Reference source not found.**).

Box 10. Policy analysis for inclusive STI policies

UNCTAD conducts STI Policy reviews (STIP Reviews) in developing countries to assess their national innovation systems and build their capacities to design and implement STI Policies aligned to their national development strategies and the SDGs. UNCTAD has conducted STIP Reviews in 16 developing countries and as of November 2019 was conducting STIP Reviews in Dominican Republic, Ethiopia, Uganda and Zambia. Other countries that have indicated their interest to conduct STIP Reviews include Botswana, Nigeria and Viet Nam.

UNESCO is undertaking several projects which contribute to international cooperation and enhancing national ecosystems for innovation: These projects include STEM and Gender Advancement (SAGA) project and the Global Observatory on STI policy instruments (GO-SPIN). Both projects propose assessment tools to identify gaps in policies and actions linked to rapid technological change. SAGA provides tools to governments that aim to reduce the gender gap in STI fields at all levels of education and in research through increasing women's visibility, involvement and recognition. To date, SAGA has been carried out in 8 countries to assess gender inequality in STEM and now pilot countries (e.g. Argentina, Gambia, Province of Quebec, Sudan, Uruguay) are working on adjusting their STI policies to remedy barriers. GO-SPIN maps national STI environments and policies to identify gaps, which allow for more evidence-based decision making in the STI policy domain. The mapping includes policies on women and youth in STI and traditional and indigenous knowledge in various countries.

Sources: UNCTAD and contributions from UNESCO.

[105] For more information, see E/2018/31-E/CN.16/2018/4 and E/2019/31-E/CN.16/2019/1.
[106] For more information, see E/HLPF/2019/6.
[107] For more information, see https://aiforgood.itu.int/

Box 11. UNIDO's Global Eco-Industrial Parks Programme (GEIPP)

Production methods must become cleaner and more efficient for countries to achieve sustainable development. The Global Eco-Industrial Parks Programme, a project of the United Nations Industrial Development Organization (UNIDO) and the Swiss Secretariat for Economic Affairs (SECO) aims to demonstrate the sustainability and benefits of making industrial parks greener through improved resource productivity and by making businesses more inclusive in economic and social performance. The programme is taking place 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 projects collaborate 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.

Box 12. FAO's Youth Entrepreneurship and Innovation Network

FAO has implemented several programmes to support youth entrepreneurship and innovation. Some examples are:

#HackAgainstHunger Innovation Challenges: bringing together diverse public and private sector experts to mentor young innovators and agripreneurs to develop high-potential digital solutions to address challenges faced by food and agriculture systems, including through the use of frontier technologies and sustainable business models for the development and adoption. The challenges have been launched both in partnership with other development agencies and universities, closely linked to high-level global and regional conferences to increase advocacy and awareness for the need to strengthen the national capacity to innovate and invest in agribusiness, in particular related to youth employment. http://www.fao.org/about/meetings/youth-in-agriculture/hack-against-hunger/en/

Digital Innovation and Entrepreneurship Workshops: Following these challenges, and with a view to increase our engagement beyond hackathons, we have also invited several of the winning innovators to FAO to attend conferences, network, and participate in a Bootcamp where they meet with FAO technical experts in the areas specifically related to their innovations to receive hands-on advice and share insights on key areas in digital agriculture. http://www.fao.org/e-agriculture/node/15702

FAO-KT Youth Entrepreneurship and Innovation Incubator: Private sector partnership to focus on digital technologies, including frontier technologies, for agrifood and engaging youth in smart farming and agribusiness to strengthen the national capacities through mentorship and training in Asia. http://www.fao.org/news/story/en/item/1197915/icode/

Source: Contribution from the Food and Agriculture Organization of the United Nations.

International cooperation also contributes to increasing the understanding of the possible impacts of frontier technologies on societies, economies and the environment. Given the complexity and speed of technological change, this change could outpace the capacity of governments to grasp its consequences fully. Therefore, assessing the impact of frontier technologies is vital. In this regard, the Commission on Science and Technology for Development and the Technology Facilitation Mechanism (TFM), in response to General Assembly resolutions A/RES/72/242 and A/RES/73/17, have considered,

in a coordinated manner within their respective mandates, the impact of rapid technological change on sustainable development. [108]

The TFM provides a platform for inter-agency country-level engagement as well as global multi-stakeholder deliberations and consensus building on STI for the SDGs including emerging technologies (see Box 13**Error! Reference source not found.**).

Box 13. Technology Facilitation Mechanism

The United Nations Technology Facilitation Mechanism (TFM) was created by the Addis Ababa Action Agenda to support the implementation of the Sustainable Development Goals (SDGs) and launched by General Assembly through the 2030 Agenda on Sustainable Development in September 2015. The TFM comprises of an Interagency Task Team on Science, Technology and Innovation for the SDGs (IATT), the Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals, and the Online Platform. The IATT is co-convened by UNCTAD and DESA. As manded, 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, and also to help to facilitate development, transfer and dissemination of relevant technologies for the SDGs. As part of this work, several initiatives such as that of STI roadmaps for the SDGs are underway. Emerging and frontier technologies are also deliberated annually at the Forum.

Source: Contribution from DESA.

The CSTD, 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 latest sessions. In particular, the CSTD has provided recommendations to ECOSOC that encouraged the international community to advance its understanding of risks and benefits and policy options to steer innovation in ways that leave no one behind. The CSTD has encouraged countries to undertake strategic foresight and technological assessment initiatives to better understand the socio-economic and environmental implications of new and innovative technologies.[109]

Other international cooperation activities that could be promoted in the context of the CSTD is the creation of a network of social entrepreneurs for the dissemination of innovative business models using frontier technologies to address developmental issues. Such a network could facilitate the dissemination of innovative business models. First movers are very important because they show how frontier technologies could be applied in a way that is not only effective in addressing an SDG, but also economically viable and demand-driven. However, equally important is the dissemination of the successful business models, which create an ecosystem of innovative businesses addressing different aspects of SDGs and reaching the scale required to promote enduring progress towards the goals. Such a network should engage businesses that offer frontier technology-based products and services that contribute to achieving the SDGs. The engagement of the business community will enable the scale-up of inclusive and sustainable innovative solutions to the level that could promote the transformations required for achieving sustainable development. At the national level, governments could promote network of social businesses, entrepreneurs and practitioners. At the international level, the CSTD could foster such a platform in collaboration with other.

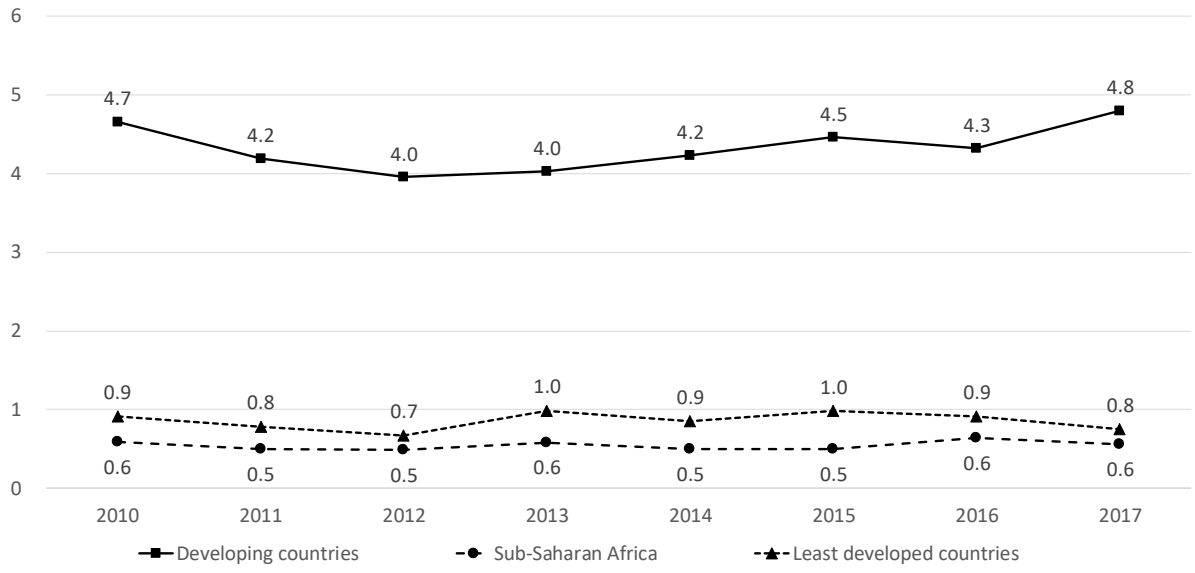
[108] For more information, see E/CN.16/2019/2 and E/HLPF/2019/6.
[109] E/RES/2019/25.

C. Official Development Assistance

Through technical cooperation programmes, international collaboration has supported countries in building their national STI capacity, including in frontier technologies. Technical cooperation delivered through Official Development Assistance (ODA) is an important source of technical and financial support to developing countries. ODA to developing countries targeting some of the areas that more directly contribute to building STI capacities of countries has not increased over the past decade. These are the ODA commitments reported under post-secondary education, ICT, industrial development, technological research and development, research and scientific institutions, and import support of capital goods. In 2010, USD 4.7 billion of ODA commitments were reported in these sectors to developing countries. ODA reduced at the beginning of the decade to USD 4.0 billion in 2012 and 2013, and it has recovered recently but only to reach about the same 2010-level, USD 4.8 billion in 2017 (Figure 5). More worrying is that ODA on those sectors directed to some of the group of countries with the lowest STI capabilities has even decreased over this period. It decreased from USD 0.9 billion in 2000 to USD 0.8 billion in 2017 for the group of the least developed countries, and it remained about the same throughout this period (USD 0.5 billion to USD 0.6 billion) for the group of countries in Sub-Saharan Africa.

Figure 5. Official development assistance for sectors associated with scientific, technological and innovative capacity, 2000-2017

(USD Billion, constant prices)



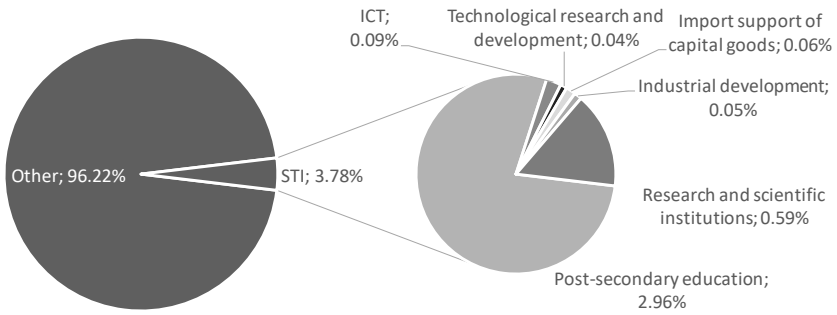
Source: UNCTAD calculations based on data from the OECD Creditor Reporting System.

Notes: Includes ODA commitments reported under post-secondary education, ICT, industrial development, technological research and development, research and scientific institutions, and import support of capital goods. Group of the least developed countries includes Samoa (graduated in 2014), Maldives (graduated in 2011), and Cape Verde (graduated in 2007).

Moreover, in 2017, only 3.78 per cent the ODA commitments to developing countries were reported under sectors associated with science, technology and innovation (Figure 6). When considering the breakdown by sectors, only 2.96 per cent of ODA was 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 of capital goods, 0.05 per cent to industrial development, and 0.04 per cent to technological research

and development. The levels of ODA dedicated to these sectors must increase. These are unquestionably key sectors for increasing the capacity of developing countries to harness science, technology and innovation for sustainable development, and they have long-lasting spillover effects in all areas of the SDGs.

Figure 6. Share of ODA for sectors associated with scientific, technological and innovative capacity in developing countries, 2017



Source: UNCTAD calculations based on data from the OECD Creditor Reporting System.

VI. Policy considerations

A. Creating the ecosystem for inclusive and sustainable innovation on frontier technologies

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 experience with fixed or mobile broadband and by promoting and imporving users' capabilities and 'Internet access culture' through the education system among youth and ad-hoc initiatives for the population at large, particularly among women and girls as well as disadvantaged groups.

Engage local industry: Governments should engage the local industry in the continuous improvement of curricula through participation in advisory boards, practical courses, TVET offers, applied senior projects and research theses.

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

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

Life-long learning and retraining programs: New technologies demand new skills, so the labour force should be trained to acquire these skills also during their careers. Governments should promote adult learning and retraining programs that help match the labour market's evolving demands and facilitate transition across jobs.

Ensure the required legal and regulatory system: Governments should ensure that the legal and regulatory system encourages the ethical use of frontier technology in public and private sectors; for example, by regulating issues of data ownership and privacy and by requiring technological impact assessments of public sector technological 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 also reinforce technology transfer at the national and regional level, and thus strengthen linkages and collaboration between academia, research centres and private sector for the development of frontier technologies.

B. Providing directionality to technological change and mitigating risks

Set direction, basic principles and ethical guidelines: Given the rapid development of technologies, and based on foresight and technological assessment, government has to play a supporting role by setting strategic direction in the application of new technologies, basic principles as well as ethical guidelines, while involving the private sector, academia and other stakeholders in the policy-making process, making full use of possibilities that data sharing, re-use and cross-border data flows can provide.

Facilitate adaptation to the local context and culture: Governments should promote localisation of SDG solutions based on frontier technologies to the context and culture (including language, values and norms) with the participation of local knowledge producers and innovation stakeholders.

Establish a periodic dialogue: Governments should establish a periodic dialogue among various stakeholders (government, academia, research centers, private sector, 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 and Ministries of Labour and labour unions in national planning of Digital Development Agendas (and vice versa engaging the digital sector in National Labour Planning) to have the appropriate level of understanding of the digital disruptions and transformations in their national labour market, and to plan proactively to mitigate associated risks through regulation.[110]

Promote decent digital jobs: Governments should promote decent digital jobs, fair compensation and balanced work-life relations for digital employees and freelancers; including potential establishments of syndicates for digital workers. [111]

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

Establish digital platforms: Governments should establish digital platforms for enhancing the link between job seekers and employers and for providing updated information to users about the needed skills and available training centres.[112]

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

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

[110] Contribution from the Economic and Social Council of Western Asia.
[111] Ibid. (ESCWA)
[112] Ibid. (ESCWA)

C. International cooperation

Develop multilevel and multivector policies: The international community should assist the development of multilevel and multivector policies (with its subsequent evaluation and adjustment), taking into account the rates and characteristics of development of different countries, to maximize the benefits associated to rapid technological change and mitigate the risk of these technologies widening or creating the new inequalities within and across countries.[113]

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

Connect innovative firms around the world: International organisations and governments should promote the collaboration of start-ups as well as innovative enterprises from different parts of the world with one another and facilitate their collaboration, provide synergy for innovation and social benefits.

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

Share experiences: The Commission should continue to promote and facilitate the sharing of experiences, through its sessions, meetings, training, workshops, and the Commission's website and curated documents and other materials, on challenges faced and solutions found in dealing with the effects of rapid technological change, for countries to draw on and implement according to 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, 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, in which volunteer mentors in member countries with experiences on rapid technological change can give advisory service for demanding countries.

Assist in bridging the multidisciplinary digital divides: The international community, including the Commission and the Multistakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum) should further commit to assist governments and partners in setting a systematic and holistic approach in bridging the multidisciplinary digital divides to ensure that everyone benefits from the emerging digital society though increase access to infrastructures, increase access to knowledge through specialized platforms, training, finance, etc.

Harness existing global platforms: The international community, including the Commission, should harness existing global platforms, including relevant UN forums, to conduct a dialogue at global, regional and national levels, between digital companies and digital workers and other stakeholders,

[113] Contribution from the Russian Federation.

to devise mechanisms to maximize benefits and minimize risks from rapid technological changes for all.[114]

VII. Questions for discussion

The following are some discussion questions to further the dialogue related to harnessing rapid technological change for inclusive and sustainable development.

A. Creating the ecosystem for inclusive and sustainable innovation on frontier technologies

- How could governments better support the creation of ecosystems for innovation in frontier technologies for inclusive and sustainable development?
- What are the most effective ways to support the improvement of skill levels for harnessing rapid technological change?
- How can STI policies ensure that no one is left behind in a world of rapid technological change?

B. Providing directionality to technological change and mitigating risks

- Can you provide examples of STI policies/projects/initiatives intended to promote and give directionality to technological change to make it work for inclusive and sustainable development?
- Are there policies/projects/initiatives that mitigate the potential negative effects of rapid technological change on inequality?
- Are any of these policies/projects/initiatives directed to women, youth, people with special needs or other groups facing specific challenges? How have the policies targeted inequalities?
- What are the challenges in implementing these policies/projects/initiatives?

C. The role of international and inter-regional collaborations

- What are the actions that the international community, including the Commission on Science and Technology for Development, can take to contribute to maximizing the benefits associated to rapid technological change and to mitigate the risk of these technologies widening or creating new inequalities within and across countries?
- Can you give any success stories in this regard from your country or region?

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[114] Contribution from the Economic and Social Commission for Western Asia.

Annex 1. 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				
Company	**Sector**	Purely digital	Digitally enabled	Not necessarily digital	Physical	Financial	Human	Intellectual property	Hybrid	Quality	Customization	Combination	Access/convenience	Price	Network effects	Specific new customer segment	Lock-in existing customers	Other companies (B2B)	Brand and marketing	Sales channel	Sales model	Customer relationship mngmnt	Make	Buy	No impact on sourcing	Suppliers	Customers	Competitors	Multiple parties	No one else 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	non-transparent	Keywords
Babyl	health		x		x	x	x		x	x	x	x	x	x	x	x					x	x	x						x	x	x	x	x	x		x					x	x					x	Platform, intermediate
Bloc	employment	x					x	x	x		x					x			x				x						x	x	x		x	x						x							x	Platform, career advice (not necessarily intermediating)
Bridge Int'l Academies	education	x					x	x		x			x			x						x	x						x	x				x								x			x	x	x		Platform for scripted lessons, school management
Capway	financial	x				x	x		x	x		x	x	x		x			x		x	x	x						x			x			x	x					x	x						x	Platform, financial services for unbanked, low-cost
Connected Agriculture Platform for Punjab (CAPP)	agriculture		x			x	x		x			x	x	x	x	x					x	x	x			x						x				x							x						Platform, intermediate
FarmBetter	agriculture	x					x				x		x	x		x						x	x						x			x		x							x			x					Platform, intermediate
Fenix	energy		x		x	x			x	x			x	x		x	x					x	x						x	x		x	x	x	x					x	x			x				System-in-a-box, lease-to-own, platform
Haqdarshak	welfare		x			x	x		x	x	x	x	x	x		x				x	x	x	x			x	x		x		x	x			x					x							x	Platform, intermediate
ITT, Tata Power, Rockefeller Foundation	energy		x		x	x		x	x			x	x	x		x					x	x	x						x	x	x		x	x						x			x	x	x		Utility-in-a-box, on-bill financing, mini-grid
Kheyti	agriculture		x		x	x	x		x	x		x		x		x						x	x						x	x	x		x	x		x				x			x				greenhouse-in-a-box, advisory, intermediate financial services
Lenddo	financial	x				x		x		x		x			x	x		x	x			x	x			x				x	x	x	x	x						x			x				Platform, intermediate, credit scores
Mindspark	education	x					x	x	x	x	x	x	x	x					x				x						x	x		x	x	x								x	x				x	Platform, digital learning
Mobihealth	health		x		x	x	x		x	x	x	x	x	x	x	x					x	x	x		x					x	x	x	x			x				x			x				x	Platform, intermediate
mobile phone providers	technology		x		x	x			x				x	x	x	x	x	x	x			x		x						x		x		x	x			x	x	x		x		x	x	x		Phone networks as digital platforms
mPharma	health		x		x	x	x		x	x		x	x	x	x	x		x	x		x	x		x		x				x	x		x	x	x				x			x			x			Streamlined pharma supply chain
Mpost	logistics		x		x							x	x	x		x						x			x					x		x				x				x			x				x	Platform, intermediate, mobile number as physical address
Mr Green Africa	recycling		x		x	x	x		x	x		x	x	x				x		x	x			x		x						x		x							x	x					x	Streamlined value chain, recycling, social impact for suppliers
Muskaan Dreams	education		x		x		x		x	x	x	x	x			x				x		x	x			x	x		x			x		x							x		x				x	Digital learning classrooms in rural government schools, teacher training
Musoni	financial		x			x	x		x	x		x	x	x		x					x	x	x						x	x	x	x	x		x				x			x					Bank network, only money money
Project Circleg	health			x	x			x	x	x	x	x		x		x						x	x				x				x	x		x	x					x				x				Prosthetics developed for developing country context, recycling
Shortlist	employment		x				x	x	x	x	x	x	x			x		x	x		x	x	x				x				x			x		x					x	x					x	Platform, intermediate
Tai	education	x						x		x	x	x				x			x			x	x				x				x			x							x	x		x				Platform for personalised learning, AI, studying in learning centres
Yoco	financial		x		x	x			x			x	x	x		x		x		x	x	x	x	x					x		x	x	x	x	x						x							x	Platform, point-of-sale hardware
Zenvus	agriculture		x		x	x	x	x	x	x	x	x				x	x		x	x		x	x							x	x	x	x	x	x						x	x					x	Platform, advisory, smart sensors, IoT

Source: UNCTAD.