

Chapter III.G

Science, technology, innovation and capacity building

1. Key messages and recommendations

Science, technology and innovation (STI) solutions have great potential to support progress on the Sustainable Development Goals (SDGs), including through promoting sustainable industrial transformation. Sustainable industrial policies can be a useful strategic approach to building technological capabilities and directed structural change. To progress on these fronts, governments need to create an enabling domestic environment for firms to enhance absorptive capacities, including providing the necessary infrastructure and fostering an enabling policy environment. Economic incentives and support for firms are also crucial, including measures to support firms' access to finance as well as targeted incentives for specific technologies. The international environment, including intellectual property protection, also greatly influences a country's ability to build technological capabilities.

While the adoption of new and emerging technologies can promote sustainable development, it has also given rise to new risks and policy challenges. Governments need to be cognizant of recent technological trends and understand the different impacts these technologies can have on various segments of society. Increased digitalization has promoted greater efficiency gains, but it has also been associated with the broader trends of rising inequality and job polarization. While financial technology (fintech) has fostered financial inclusion, some innovations are generating risks to financial stability. In this context, institutions, policy and regulatory frameworks must keep pace with the rapidly evolving technological landscape.

The energy crisis presents an opportunity to accelerate the sustainable energy transition. In 2022, global spending on the energy transition rose to a new record, driven by the energy crisis and targeted policy support measures in a few large economies. Yet, current investments in sustainable energy sources remain insufficient to meet international climate goals. Most developing countries still face large shortfalls in sustainable energy investments despite recent innovations in energy technologies and systems that are making it increasingly feasible to decouple economic progress from greenhouse gas emissions. There is a strong case for government policies to support the development and adoption of low-carbon and environmentally friendly technologies to catalyse the energy transformation. Stronger support from the international community and private sector are also needed to mobilize sufficient financial resources towards climate investments.

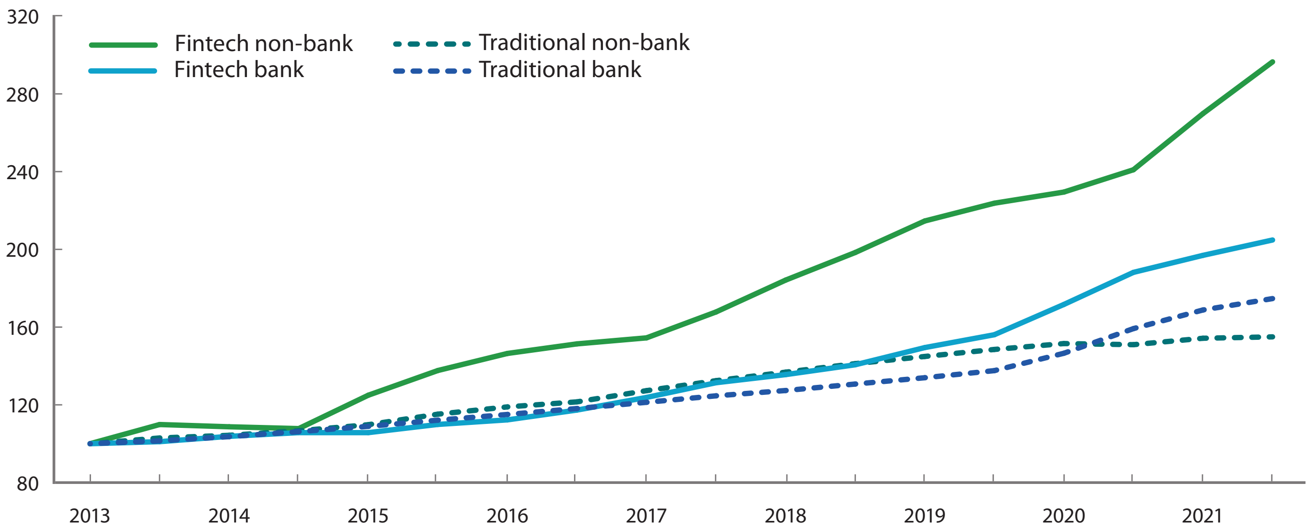
The United Nations system has adopted multiple actions to boost the STI capacities of countries. These actions include technical and financial support, knowledge and information-sharing, help with policy design, and norm and standard setting. The continued collaborative efforts of Member States, supported by the United Nations system, are needed not only to facilitate developing countries' adaptation of new technologies for sustainable development but also to align finance, investment and technology to enable countries to recover better from recent and ongoing crises.

2. Digital finance and financial inclusion

Trends in financial technology

Fintech has continued to evolve and diversify, creating new opportunities and policy challenges. Fintech is increasingly disrupting the core financial services traditionally provided by banks and has gained stronger momentum following the COVID-19 pandemic.[1] In 2021, lending by non-bank fintech companies increased by 23 per cent, significantly outpacing lending by traditional banks and traditional non-banks, which grew by 10 per cent and 3 per cent, respectively (figure III.G.1). Fintech innovations are happening most rapidly

Figure III.G.1
Asset growth of fintech and traditional lenders
(1H 2013=100)



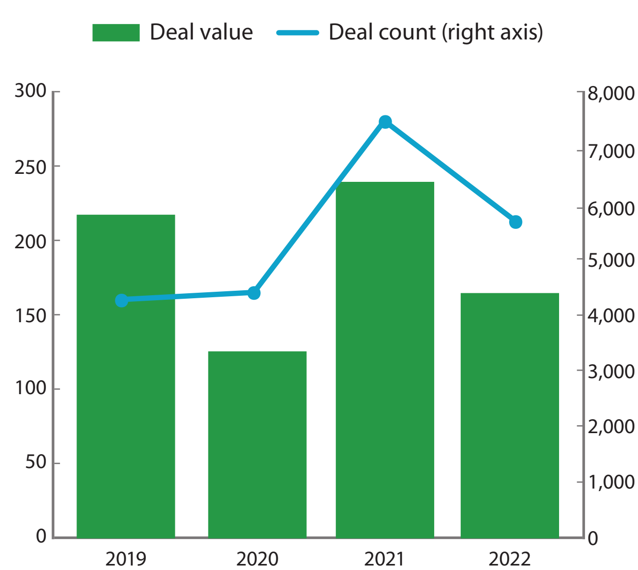
Source: IMF Global Financial Stability Report April 2022.

in the payments sector, enabled by policies such as open banking in developed countries. In developing countries, the expansion of large technology conglomerates (BigTech) into financial services has been more rapid and broad-based than in developed economies.

Global fintech investment declined in 2022, but investors remained optimistic in several subsectors and regions. Investment in fintech fell to $164.1 billion in 2022, after reaching a record high of $238.9 billion in 2021 (figure III.G.2). While the weak economic outlook and high uncertainty dampened investor sentiment, global fintech investment in 2022 was still the third highest in value and the second highest in deal volumes. Fintech investments declined in the Americas and in Europe, but rose further in the Asia-Pacific region, slightly surpassing its 2021 peak. Investments in the cryptoassets and blockchain space declined, amid sharp volatility in the crypto market and growing regulatory scrutiny in this area. In contrast, investment in regulatory technology (RegTech) grew by over 50 per cent, reaching a new high of $18.6 billion in 2022. The rapid growth in RegTech reflects strong demand for technologies to manage ongoing regulatory changes, including in digital payments, crypto markets and environmental, social and governance (ESG) standards.

Fast-growing fintech firms have the potential to further broaden access to financial services but are creating challenges for regulators. The shift towards fintech lending has been accompanied by rapid growth in new, innovative financial services, including those that circumvent the financial intermediation chain such as peer-to-peer lending and decentralized finance. While these financial innovations can potentially help to increase the efficiency, inclusivity and affordability of financial services, they have also given rise to systemic risks with implications on financial stability (see chapter III.F). For example, decentralized finance—a crypto-based financial network that is often highly leveraged—is susceptible to market, liquidity and cyber risks.[2] Furthermore, the linkages between fintech companies and traditional banks also pose challenges in the form of regulatory arbitrage and contagion. Growth in digital financial services has exacerbated risks from cyber incidents, data protection and privacy breaches, digital fraud and new forms of financial exclusion. Many jurisdictions still lack regulations on such risks carried by new technologies.[3] In some developing countries, mobile money platforms have become systemically important, with great divergence in regulatory protection between jurisdictions.[4]

Figure III.G.2
Global fintech investment
(Billions of United States dollars) *(Number of deals)*



Source: KPMG. 2023. Pulse of Fintech H2'22.

The growing presence of BigTech in financial services has the potential to further deepen financial inclusion but could generate financial stability risks. BigTech platforms have a unique business model that is often based on the exploitation of network externalities, leveraging the extensive use of customers' data across business lines. This can lead to benefits in the provision of financial services, including the potential to offer greater and more tailored products at lower prices. BigTech platforms have the potential to promote financial inclusion through combining financial services with their traditional business models such as social media and e-commerce platforms that are often ubiquitous. However, BigTech can generate financial stability risks, including through operational interconnectedness (for example, through cloud service providers) and financial interconnectedness (where BigTech firms provide the front-end of financial services such as credit, while banks provide the funding and take on the majority of credit risk on their balance sheets). The cross-border and cross-sectoral nature of BigTech firms also makes them particularly challenging to regulate. These developments highlight the importance of updating regulatory frameworks, including consumer protection laws, to ensure that risks associated with new fintech services are well contained.

Digital payments

Digital payments have continued to expand strongly in tandem with rapid growth in new forms of payments, such as e-money and mobile wallets. In developing economies, the share of adults making or receiving digital payments has grown rapidly in recent years, rising from 44 per cent in 2017 to 57 per cent of all adults in 2021.[5] This trend has also been seen in low-income countries, where the share rose from 22 per cent of adults in 2017 to 35 per cent in 2021. In low-income countries, digital financial services are driven by mobile money transactions, which grew from about 40 per cent of gross domestic product (GDP) in 2019 to 70 per cent of GDP in 2021.[6] While overall transactions growth is projected to moderate amid a weakening global economic outlook, the shift towards digital payments is likely to continue. Traditional payment methods (cards, credit transfer, direct debits) still constitute over 80 per cent of all non-cash transactions, but the usage of new payment instruments (instant payments, e-money, mobile wallets and QR codes) is fast gaining traction.

The rapid adoption of mobile payments during the pandemic is reflected in the strong expansion in mobile money accounts worldwide. In 2021, the number of mobile money accounts worldwide increased by 18 per cent to 1.35 billion accounts, with a 31 per cent increase in the value of transactions to $1 trillion.[7] This trend contributed to the overall growth in the banked population, especially in economies where financial access via commercial banks is diminishing. Indicators of SDG target 8.10 reflect a declining number of commercial bank branches or ATMs per 100,000 adults in recent years, in part due to cost-cutting efforts by banks.[8] Underserved regions—especially in Africa and Asia—were predominantly reached by innovative financial intermediation measures, including mobile money agents, whose number per 100,000 adults almost doubled globally (from around 450 to 880) between 2019 and 2021.[9] Of note, 26 per cent of adults in sub-Saharan Africa used mobile money as a way to save in 2021, rising from 15 per cent in 2017.

The growing use of digital payments is paving the way for a wider adoption of financial services. The strong expansion of digital payments is serving as a catalyst for the use of other financial services. Almost two thirds of digital payment recipients also used their account to store money for cash management; 40 per cent used their account for savings; and 40 per cent to formally borrow money. [10]

Policy support helped to facilitate the adoption of digital financial technologies during the COVID-19 crisis. Across developed and developing countries, governments introduced new policies and regulatory measures which helped to promote the more widespread usage of digital technologies, including digital financial services. Governments are also promoting electronic payment for duties, taxes, fees and charges collected by customs as part of a broader effort to facilitate trade and increase customs revenues.[11] In efforts to encourage the use of mobile money, many countries temporarily lowered or waived transaction fees and increased limits on digital transactions. Some governments also launched regulatory sandboxes to test innovative digital financial services and postponed the planned imposition of stricter regulations on fintech companies.[12]

Financial inclusion

Fintech is playing a key role in bolstering financial inclusion. By easing market frictions and reducing the costs of financial services, digital financial innovations have broadened access to finance for previously excluded or underserved populations. The COVID-19 pandemic underscored the important role that digital infrastructure can play in rapidly delivering financial services and social assistance to people. Amid strict lockdowns and mobility restrictions, the pandemic accelerated the global shift towards the use of digital financial services, particularly mobile money. Fintech is creating new opportunities to drive financial inclusion by increasing account ownership among the unbanked and expanding the use of financial services among those who already have accounts (see chapter III.B). For example, in developing economies, 39 per cent of adults opened their first account at a financial institution specifically to receive a wage payment or receive money from the government.[13] Nonetheless, 85 million unbanked adults still receive government payments such as wages and government transfers in the form of cash. Digitalizing some of these payments will help to spur an increase in account ownership. Many segments of society still lack access to the Internet and digital devices (see box III.G.1), preventing them from fully reaping the gains of the growth in fintech.

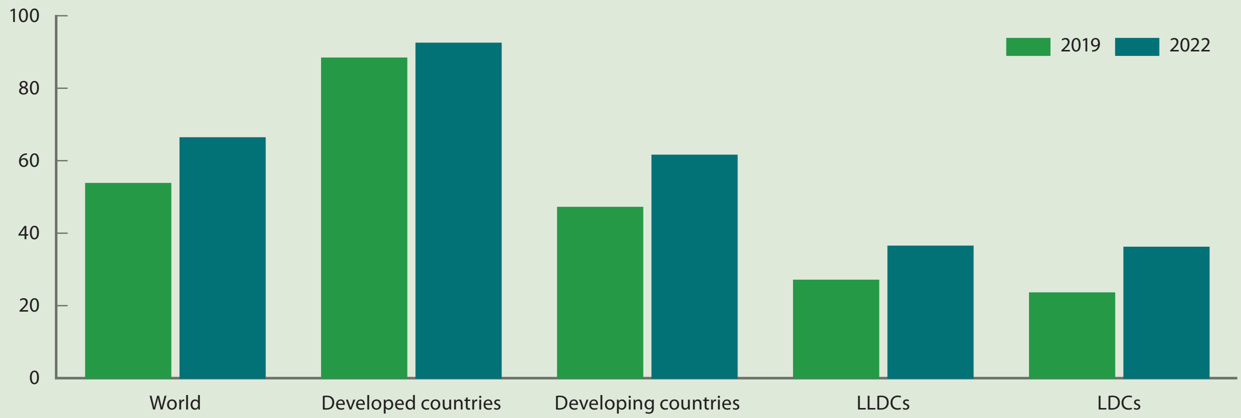
Digital technologies are reshaping the global remittances landscape. Fintech innovations have been instrumental in reducing the cost of cross-border payments, notably in the case of remittances. The pandemic fueled the adoption of digital remittances, as lockdowns prevented migrants from accessing traditional remittance methods such as over-the-counter cash remittances and informal networks. In 2021, the number of international remittances via mobile money grew by 48 per cent to $16 billion.[14] However, digital channels still account for less than 1 per cent of total transaction volume,[15] illustrating the immense potential for the further digitalization of remittances. This could help to improve the affordability of remittance services, while the increase in access and usage between transaction accounts could foster greater financial inclusion. Of note, over 40 per cent of mobile money providers still do not offer any international remittance services to their customers due, in part, to strict or opaque licensing requirements in some countries.[16] In this context, the easing of regulatory barriers could help innovative remittance services to flourish.

Box III.G.1
Recent digital trends

The acceleration in digital trends presents both immense opportunities and challenges for sustainable development. The COVID-19 pandemic has sped up the pace of digital transformation and the adoption of digital technologies. Many of these technologies have the potential to boost efficiency and strengthen resilience while supporting a sustainable energy transition. At the same time, the growing digitalization of economies is bringing about new risks and challenges. The pandemic has made digital connectivity a growing necessity, benefiting those with already strong technology capacities and leaving others further behind. This has exacerbated existing digital divides, contributing to deeper inequities between and within countries.

Internet usage has continued to expand worldwide but progress is highly uneven across regions. According to the latest data from the International Telecommunication Union (ITU), 5.3 billion people, or 66 per cent of the global population, were using the Internet in 2022, an increase of 6.8 per cent compared to 2021 and 27 per cent higher than in 2019. The aggregate figure, however, masks stark disparities across regions and countries, with a global total of 2.7 billion people still offline and not using the Internet regularly. In least developed countries (LDCs) and landlocked developing countries (LLDCs), on average, only 36 per cent of the population uses the Internet, compared to 92 per cent in developed countries (figure III.G.3).

Figure III.G.3
Individuals using the Internet, by country groups
(Percentage)



Source: ITU World Telecommunication/ICT Indicators database.

Internet access and digital devices remain unaffordable for many vulnerable groups in developing countries, exacerbating the cost of digital exclusion. Amid a sharp drop in incomes due to the pandemic, the affordability of broadband services worsened for all income groups in 2021, with the exception of high-income economies. For LDCs, the median monthly price of the cheapest broadband subscription with at least 5 GB of data is 20 per cent of gross national income (GNI) per capita, which is in sharp contrast with Europe where the same bundle costs only 1.3 per cent of GNI per capita.[a] In addition, digital devices still remain unaffordable for many segments of the population, particularly in low- and middle-income countries. In 2022, the average cost of a smartphone was a mere 2 per cent of monthly income in North America, but this figure stood at 53 per cent in South Asia and 39 per cent in sub-Saharan Africa, meaning that a smartphone represents a major purchasing decision for many people in these regions.[b]

The digital gender divide remains wide in many developing countries. In 2022, 69 per cent of all men were using the Internet compared to 63 per cent of women, representing a small reduction in the ratio compared to 2019. However, when measured by the absolute difference between the number of men and women online, the gender gap has increased by 20 million.[c] While the developed countries and small island developing States (SIDS) have achieved gender parity in Internet usage, many low- and lower-middle-income countries still face persistent large gaps of over 10 percentage points, which are wider today compared to pre-pandemic levels. Recent data has also showed a slight widening in the gender gap for smartphone ownership, with women 18 times less likely than men to own a smartphone in 2021, compared to 15 times in 2020.[d]

a ITU. "The Affordability of ICT Services 2021". Policy brief.
b Alliance for Affordable Internet. "2022 Prices and Affordability of Smartphones and Feature Phones by Country (database)".
c ITU and UNESCO. 2022. *The State of Broadband 2022: Accelerating Broadband for New Realities*.
d GSMA. "The Mobile Gender Gap Report 2022".

Targeted policy initiatives are needed to strengthen digital financial inclusion, including improving women's access to digital technologies. In contrast to the gender gap in overall Internet access, the gender gap in account ownership shrank for the first time in 2021, narrowing from 9 to 6 percentage points in developing economies.[17] However, there remains a considerable gender gap in the use of accounts for digital payments, with 52 per cent of all women using digital payments in 2021 compared to 61 per cent of men, reflecting a gap of 9 percentage points. In addition, the gender gap in access to financial services remains significant, particularly in many low- and middle-income countries. There are signs that mobile money accounts may be helping to close the gender gap. However, women are still 7 per cent less likely than men to own a mobile phone, a key prerequisite for mobile money use.[18] A recent study found that while an increase in the use of fintech is associated with a narrowing of both the class and rural divides, it has no impact on the gender divide, implying that fintech development alone is insufficient to close the gender gap in access to financial services.[19] Importantly, fintech needs to be complemented by targeted policy strategies, including those aimed at improving women's access to the Internet as well as their financial literacy and digital skills.

While digital financial services have enabled a wider reach to vulnerable populations, they have also created new risks to consumers, including digital fraud. The introduction of digital payments to low-income adults has been accompanied by risks, such as fraud and phishing scams, over-indebtedness in digital credit, and incomplete or incorrect information with regard to fees and costs of financial products. In this context, there is a need to strengthen customer protection and redress mechanisms. Authorities should also enhance the digital and financial education of vulnerable and underserved groups, including the poor, women, rural dwellers and micro-, small- and medium-sized enterprises (SMEs), enabling them to reap the benefits of account ownership and to better detect and avoid digital fraud.

3. Science, technology and innovation and sustainable industrial transformation

Technological change and innovation are major sources of growth and sustainable industrial transformation. Industrial transformation depends on firms progressively acquiring and mastering technological capabilities. Amid a lack of dynamism, many firms in developing countries are still far from the technology frontier and thus unable to close productivity gaps and create decent jobs.[20] The broader digital divide identified in box III.G.1 is mirrored, and even exacerbated, in stark technology divides across firms. Closing these gaps is key to achieving sustainable industrial transformations.

Efforts to close the technology divide among firms are taking place amid several global trends that have increased the policy focus on production technologies. First, the rise of advanced digital production technologies—sometimes referred to as "Industry 4.0"—is raising the bar for firms to become competitive or join global production networks, calling into question traditional industrial development pathways around exports in low-tech and low-wage sectors. The pandemic has further increased pressures for greater automation and flexibility in production processes. Second, the urgency to combat climate change has led to accelerated efforts to develop and massively speed up the deployment of low-carbon and clean technologies. These broad trends are shaping the global technology landscape and informing countries' efforts to create preconditions and provide support to firms for the upgrading of their technological capabilities.

3.1 Global trends

i) Advanced digital production technologies—towards "Industry 4.0"

Advanced digital production technologies are reshaping production processes. Advanced digital technologies, such as artificial intelligence (AI), big data analytics, cloud computing, the Internet of Things (IoT), advanced robotics and other digital technologies, are being increasingly applied in various combinations in manufacturing and industry. Together, these technologies, which some are calling Industry 4.0 or the Fourth Industrial Revolution, allow for increased automation and the growing use of "smart" or intelligent manufacturing production systems. Most of them focus on automation, but an increasing number are also supported by AI that can support firms to make better-informed decisions.

Industry 4.0 technologies consist of hardware and software and are typically connected through networks and connectivity. Hardware components include modern industrial robots (robots that operate separately from workers in the execution of tasks), cobots (robots that cooperate with workers), intelligent automated systems and three-dimensional printers. Software components include information and communications technologies (ICT) such as enterprise systems, computer-aided manufacturing and design, and data analytics that leverage AI and big data. Digital networks, such as IoT, which connects machines with sensors, can collect, transmit and act on real-time data.

The adoption of digital technologies in manufacturing can lead to both productivity and efficiency gains. Such technologies enable more agile production, increased flexibility and more data-driven decision-making, offering the potential to increase input efficiency and boost productivity. For example, smart production can boost productivity by reducing downtime and maintenance costs, while the incorporation of real-time data capabilities can improve operations and lead to cost savings for manufacturers. Firm-level surveys in Ghana, Thailand and Viet Nam show that firms using advanced digital production technologies display higher productivity regardless of industry and firm size.[21] This corroborates findings at the aggregate level, where countries that actively engage with these technologies tend to exhibit much faster growth in manufacturing value added compared to those that are lagging behind.[22]

Yet, advanced digital production technologies remain extremely concentrated across countries, firms and sectors. While some emerging economies are entering into the race, large parts of the world remain marginalized from the productive dynamics of the new digital era. Moreover, even within economies actively engaging with new technologies, the share of firms using them remains very limited. This finding is consistent with the experience of previous technological revolutions, which divided the world into leading and following economies, depending on countries' involvement in creating and using emerging technologies. Based on patent and trade data on four core digital production technologies—industrial robots, CAD-CAM, additive manufacturing and machine learning—four broad categories of economies emerge:

- Frontrunners: This group includes the top 10 economies in terms of innovation and use. They account for 91 per cent of all global patent applications and almost 70 per cent of exports of all capital goods associated with those technologies, and include China, Germany, Japan, the United States and several others;
- Followers: A second group of 40 economies is actively engaging with new technologies but to a much lower extent than frontrunners. They include countries active in the production and export of digital production technologies—including advanced emerging economies such as Brazil and India—and those specialized in its use (mainly importers), composed largely of emerging economies such as Mexico, Thailand and Turkey;
- Latecomers: Included here are 29 economies with low patent or trade activity involving Advanced Digital Production Technologies (ADP). While they have marginally engaged with new technologies, it is not clear whether they will succeed in becoming followers;
- Laggards: These are economies with no or very low engagement with ADP technologies.[23]

The frontier technologies readiness index of the United Nations Conference on Trade and Development (UNCTAD) shows that countries differ greatly in their capacity to use, adopt and adapt to new digital technologies. The latest data shows that while average technology readiness has improved over the past five years, a stark disparity across countries remains, with LDCs least well prepared (table III.G.1). By geographical region, the index shows that the economies best prepared for an equitable deployment of frontier technologies are those in North America, Europe and North-East Asia, while the least prepared countries are located in sub-Saharan Africa.

Table III.G.1
Frontier technology readiness index

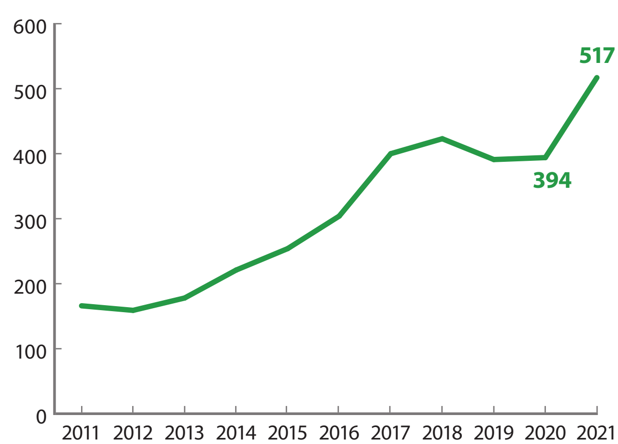
Country group	2018	2022
World	***0.43***	***0.50***
Developed	0.76	0.79
Developing	0.43	0.51
Commodity-dependent	0.25	0.32
LDCs	0.13	0.19
LLDCs	0.22	0.29
SIDS	0.30	0.37

Source: UNCTAD Technology and Innovation Report 2023.
Note: The index comprises five building blocks, namely ICT deployment, skills, R&D activity, industry activity, and access to finance. It scores 158 countries on a scale of 0 to 1, where 0 is the least ready and 1 the most.

Most manufacturing firms in developing countries are far from using advanced production technologies. Basic digital technologies, such as the Internet and mobile phones are used widely by businesses in developing countries. However, this has not translated into greater use of advanced manufacturing technologies, with many firms yet to acquire and adopt Industry 3.0 technologies, such as automation and ICT technologies, in the manufacturing process. Large gaps remain in technologies used to perform production tasks (such as tractors for harvesting or electric sewing machines in apparel). According to one survey, 83 per cent of businesses continue to use manual processes and manually operated machines to fabricate their main product (but with important variations across sectors).[24]

These inequalities are mirrored in robotics—with growth highly concentrated in a few countries and sectors. Industrial robot installations surged to a record high in 2021, with over half a million new installations worldwide, 31 per cent higher than in 2020 (figure III.G.4). Across regions, the use of robots in the manufacturing industry has accelerated, with average global robot density rising to 141 robots per 10,000 employees—more than double the level in 2015.[25] However, this trend is highly concentrated in a handful of sectors and largely driven by a small number of countries. The highest robot densities can be found in the Germany, Japan, Republic of Korea, Singapore and Sweden. Not far behind are China and the United States, with similar robot densities. Since 2020, the largest number of robots have been installed in the electronics sector, followed by motor vehicles parts suppliers. Notably, most of these new robots have been installed in China, with little activity in most developing countries. In fact, China's operational stock of industrial robots has grown by 28 per cent per year since 2016, much faster than anywhere else in the world—today it is larger than the combined stock of robots in Europe and the Americas.

Figure III.G.4
Annual installation of industrial robots worldwide
(Thousand units)



Source: International Federation of Robotics.

ii) Green and low-carbon technologies

The green economy is rapidly emerging and has become the fifth largest industrial sector by market value. The market capitalization of green equities more than doubled from \$3 trillion in 2018 to \$7.2 trillion in 2021 (reaching about 7.1 per cent of global equity markets), which was larger than retail, financial services, or oil & gas, and almost as big as the banking sector. The green economy is diversified, with energy efficiency and e-vehicles and their supply chains growing the fastest, compared to modest growth in renewable energy equipment.[26]

Green economy actions to limit climate change require deployment of low-carbon technologies everywhere at unprecedented speed and scale. Limiting global warming to 1.5 degrees Celsius above pre-industrial temperatures and reducing greenhouse gas emissions to net zero by 2050 requires major transformations worldwide—of economies and societies. Key to achieving this is the development of new low-carbon technologies and innovations, yet to a significant extent the challenge is one of rapid deployment of existing technologies at massive scale: Expanding the use of commercially viable low-carbon technologies in energy, industry, transportation and construction could reduce the global emissions gap by almost two thirds.[27] In addition to scaling up capital expenditure in low-carbon technologies and technology transfer to poorer countries, different approaches in regard to innovation policies are needed to facilitate the development of complementary innovations across various fields, such that cumulative efforts will have a transformative impact.

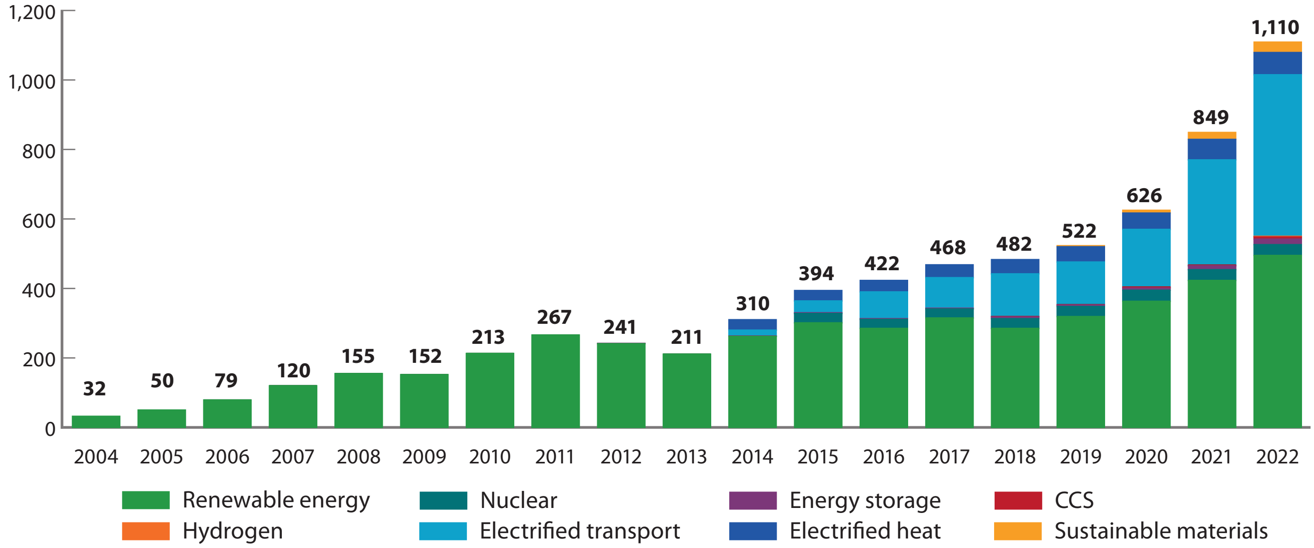
Governments have significantly stepped up efforts to accelerate the low-carbon transition. In a drive to build back better from the COVID-19 pandemic, fiscal stimulus packages have increasingly incorporated green spending, with a focus on sustainable energy. While concentrated in a few countries, the share of green funding in recovery measures greatly increased from 18 per cent in 2020 to 51 per cent in 2021, as new initiatives with longer lead times were incorporated into public budgets.[28] The large-scale financial stimulus packages show the feasibility of closing the remaining gap on the unfulfilled promise of $100 billion per year in climate finance for developing countries, especially if the political will materializes.

Global spending on the energy transition rose to a new record in 2022, driven by the global energy crisis, growing policy support and rapid technological advances. The war in Ukraine drove many countries to ramp up investment in the energy transition in efforts to bolster energy security and reduce their reliance on imported oil and gas. Investments in global energy transition almost doubled from 2020 to 2022. In 2022 alone, they rose by 31 per cent to a record high of $1.11 trillion, buoyed by record investments across all sectors with the exception of nuclear. The renewable energy sector remained the largest, with about $495 billion in new capital spending. More than 60 per cent of renewable investments were in solar photovoltaic (PV) energy. Investments in electrified transport, i.e., electric vehicles, batteries, charging stations and related technologies, grew at an incredible 54 per cent in 2022. Investments in hydrogen production and carbon capture and storage technologies remain comparatively low, but grew rapidly, effectively tripling and doubling in that year, respectively (figure III.G.5).[29]

In 2022, energy transition investments slightly surpassed fossil fuel system investments for the first time. New policies in several key markets have helped to drive the surge in clean energy investments over the past few years. The sharp increase in global fossil fuel prices relative to the cost of clean energy, including the installation of renewables such as solar and wind, has also contributed to the increased cost competitiveness of clean energy. The International Energy Agency (IEA) estimates that clean energy investments could be on track to exceed $2 trillion by 2030, 50 per cent higher than current levels.[30] The IEA also revised upwards its projections of global renewable capacity by almost 30 per cent. Renewables are now set to account for over 90 per cent of global electricity expansion over the next five years, overtaking coal to become the largest source of global electricity by early 2025.[31]

The recent rise in clean energy investments has been catalysed by targeted policy strategies to support the energy transition. Many of the recent policy measures were announced as part of pandemic recovery fiscal packages or in response to the global energy crisis. Between April 2020 and October 2022, governments worldwide rolled out $1.215 trillion in support measures for clean energy investments, with about 95 per

Figure III.G.5
Global energy transition investments
(Billions of United States dollars)



Source: BloombergNEF.
Note: Start-years differ by sector but all sectors are present from 2019 onwards.

cent of this amount announced by developed economies.[32] In the United States, the Inflation Reduction Act alone allocates $370 billion towards facilitating the energy transition, while the European Union's REPowerEU Plan earmarks additional investments of €210 billion, which includes spending for renewables and clean hydrogen infrastructure. The rapid roll-out of clean energy in China, notably renewables and electric vehicles, has been supported by a range of incentives and regulatory policies guided by official targets. Clean energy spending has also been incorporated in the national budgets of France, Germany, Japan, the Republic of Korea and the United Kingdom, among others.[33]

Developing countries, excluding China, still face large shortfalls in sustainable energy investments. The recent strong growth in clean energy investments has been concentrated in the developed countries and China. In 2022, China alone accounted for almost half of global investment in the energy transition, with the bulk of it in the renewable energy (solar and wind power) and electric vehicle sectors. In many developing countries, annual capital expenditure on clean energy has remained stagnant at 2015 levels,[34] in part reflecting the challenges that these countries face in mobilizing finance for capital-intensive, low-carbon energy projects. Amid the tightening of global financial conditions, rising public debt and narrowing fiscal space will exacerbate these financing challenges, given that public sources of finance are dominant in energy investments in developing countries. Financing for energy transitions in developing countries, excluding China, needs to quadruple by 2030 to above $1 trillion, and an estimated 70 per cent of this capital needs to be privately financed.[35]

Recent innovations in energy technologies and systems offer opportunities to accelerate the energy transition. These include technological developments in various areas, including electrified transport, solar PVs, clean hydrogen, smart grids and digital consumer technologies.

Electrified transport

Trends in the electric vehicles sector have implications for future power generation capacity needs. The electric vehicles market has continued to expand rapidly, with the sale of electric vehicles amounting to over 10 per cent of global automotive sales for the first time in 2022.[36] The recent rapid growth in electric vehicles has been supported by substantial public spending, including tax credits and consumer subsidies in large countries such as China, Germany and the United States. The further electrification of road transport would require a significant expansion of existing power generation capacities as well as an increased availability of public charging infrastructure. Moreover, the growing prevalence of larger electric vehicle models such as sports utility vehicles is expected to increase demand for larger batteries as well as the raw materials needed to produce them. In 2021, about half of the electric vehicle models available in the United States and Europe were sports utility vehicles.[37]

Solar PV cells

A third generation of solar PV cells is emerging. While current solar PV technology has the highest power density among all modern renewables, a third generation of solar PV cells has the potential to enable higher power conversion efficiency with lower manufacturing complexity and costs.[38] While their power densities would still be 10 to 100 times less than fossil fuels, they represent a feasible option at global scale, with multiple environmental advantages beyond greenhouse gas emissions. Further research and knowledge exchange could facilitate a larger-scale deployment of this emerging technology in developing countries. In addition, despite rising materials and equipment costs, production costs of conventional solar PV have continued to fall. The cost reduction for solar PV has been much faster than for any other modern renewables. Between 2010 and 2021, the global weighted average levelized cost of electricity of newly commissioned utility-scale solar PV projects declined by 88 per cent.[39]

Hydrogen

Green hydrogen is attracting interest as a new source of energy, with around 45 countries devising or having already published green hydrogen strategies.[40] Hydrogen has power densities that are six times higher than those of even the best lithium-ion batteries, which makes it a better option for long-range transport and heavier vehicles.[41] Following the adoption of the ambitious European Green Deal, many European countries are pursuing more rapid development and deployment of hydrogen technologies.[42] The industrial sector is among the most difficult to decarbonize, but green hydrogen can offer a solution. Renewable hydrogen production is rapidly expanding for refining, steel, ammonia and chemicals production, mostly combined with on-site electrolysers to avoid the need for hydrogen storage and transport.

Smart grids

Smart grid technologies can facilitate the integration of renewables into the global energy system. Given the inherent variability of many renewable energy sources, power grids need to be modernized to incorporate renewable energy into the electric distribution and transmission system. Smart grids can accentuate the viability of renewable energies, enhance the efficiency of electricity distribution and improve the reliability of energy systems. To do this, smart grids rely on the collection of data, leveraging IoT and the use of advanced sensors to monitor and control systems. Amid the growing use of electric vehicles, smart power grids can also match and integrate intermittent sources of electricity such as solar and wind power with transport systems. In developed economies, investment in electricity grids has continued to expand strongly to support the electrification of buildings, industry and transport as well as to accommodate variable renewables on the power system.[43] Despite rapid growth in energy demand, however, many developing countries are lagging in their progress towards updating their electricity grids for a green energy transition.

Digital consumer technologies

The wider adoption of consumer technologies can significantly lower primary energy demand. A range of disruptive digital consumer-facing innovations in buildings, mobility, food and energy distribution and use are readily available for local adaptation and deployment across the world. In some instances, digitally enabled home energy systems have led to energy savings of 91 per cent, though in some outliers they have instead led to increased energy usage.[44] Consumer innovations that change how energy is supplied to, generated or managed by households can also help to reduce greenhouse gas emissions. Digitalization and smart grids make it possible for consumers who generate renewable energy to also be sellers to the grid ("prosumers").

3.2 Opportunities and challenges for developing countries

The impressively rapid increase in investments and deployment of new technologies represents opportunities but also major challenges for developing countries.

Development pathways and job creation

Advanced digital production technologies could "raise the bar" for firms in developing countries and render obsolete traditional development pathways. Historically, manufacturing served as an escalator of progress because it allowed firms in developing countries to import and combine advanced technology embodied in capital goods with low-skilled labour and export to world markets (see chapter II). The spread of advanced digital production technologies is putting that model at risk and is raising the bar for firms and for countries to join global production networks. At present, robot intensity remains very low in the sectors that have typically served as entry points for developing countries, such as textiles, apparel and footwear (see above). But there are deep concerns that robotization and the adoption of emerging technologies could have large adverse effects on industrial employment, particularly in developing countries.[45] Studies on robotization show a high risk of losses in routine and manual jobs, which make up a large share of manufacturing jobs in developing countries. Many heavily traded manufacturing sectors are increasingly automated, including electronics, computers, machinery and equipment. The bar for entry and for retaining competitiveness will be rising more generally: as more tasks can be automated, labour will account for a smaller share of production costs; demands on the quality of infrastructure, logistics and connectivity, as well as educational and skills requirements, will rise.[46]

The overall impacts of trends in automation, robotization and frontier technologies remain uncertain. While many studies have predicted that frontier technologies will destroy jobs and cause major disruptions to labour markets, the evidence is still inconclusive. Thus far, the deployment of new digital technologies has not led to a rise in overall unemployment. While robots and machines are increasingly able to perform more complex tasks, thus making it easier to displace workers, advancements in technology can also spur the creation of new industries and occupations, thus generating new employment opportunities. The use of AI and robotics can also complement the jobs of skilled workers and increase relative demand for labour in non-routine tasks, such as those that require creativity, problem-solving and entrepreneurship.

At the same time, the expansion of low-carbon technologies holds the promise of sizeable job opportunities for developing countries. Over the past decade, global employment in the renewable energy sector has grown at an average rate of over 6 per cent annually, reaching 12.7 million people in 2021.[47] The solar PV industry has been the fastest-growing sector, employing 4.3 million people, or more than a third of the global workforce in renewable energy. This is followed by the bioenergy, hydropower and wind energy industries. China accounts for 42 per cent of the world's renewable energy jobs, with another 20 per cent in the rest of Asia. This reflects the region's strength in installation markets and equipment manufacturing. Given the growing potential of the renewable energy sector to create more jobs, countries need to ensure that appropriate policies are put in place to ensure the quality of these jobs and decent livelihoods for workers.

Inequalities

Advanced digital production technologies have contributed to broader trends of rising inequality and job polarization linked to digitalization. In developed countries, there is evidence that the adoption of digital technologies has contributed to greater wage inequality.[48] As routine and manual jobs, often in manufacturing and industry, disappear, those affected are forced to accept lower-skilled and lower-paying jobs, such as in services industries. In addition, digitalization more broadly is disproportionately benefiting firms that are already more productive, increasing their lead and competitiveness over other firms. Across Organisation for Economic Co-operation and Development (OECD) economies, increased inequality in firm productivity and profitability is mirrored by increased inequality in labour incomes.[49] Job markets are increasingly polarized, with a declining employment share of middle-skilled jobs and a rising share of higher-skilled jobs.[50] A study analysing robot adoption within industries found that increased use of robots reduced the employment share of low-skilled workers.[51]

The rapid growth of frontier technologies also risks widening income gaps between and within countries. Countries with a large share of high-skilled employment and technology-intensive manufacturing stand to reap the highest productivity gains from frontier technologies, leaving others behind.[52] This poses a grave challenge for many developing countries, particularly low-income countries, as well as population groups and regions where technology adoption rates remain low. The AI revolution can also widen income gaps between and within countries by shifting investment to places where automation is already established.[53] Moreover, given the uneven gender balance in occupations, men and women will also be affected differently, which may exacerbate existing gender inequalities in employment. In the agriculture sector, while emerging digital technologies hold great potential to transform agrifood systems, they also entail significant challenges (see box III.G.2).

Sustainability gains

Frontier technologies can generate productivity, energy efficiency and sustainability gains. Smart manufacturing processes can drive more sustainable production and reduce the environmental impact of industrialization. New technologies such as IoT and 3D printing can improve resource planning in order to reduce wastage, thus contributing to greater cost efficiency and sustainability. The adoption of smart manufacturing systems can also lead to greener global value chains. For instance, the use of IoT-enabled sensor technologies across supply chains enables firms to monitor, analyse and manage carbon emissions, while reducing energy consumption. This results in operational improvements and cost savings for manufacturers. In a case study of a multinational company, the use of Industry 4.0 technologies reduced power consumption in one plant by around 40 per cent, saving over $200,000 a year in energy costs.[54] A study of over 400 firms in China and Pakistan showed that the integration of blockchain technology helped to improve firms' circular economy practices, which in turn improved their environmental performance.[55]

The growing use of digital devices and services could also cause net increases in energy use, if not carefully managed. While digital technologies can enhance resource and energy efficiency, the growing digitalization of economies will increase the need for power. Digital currencies could increase energy demand strongly in coming years, given the energy intensity of some types of distributed ledger technologies that underpin digital assets. In addition, it is estimated that power demand from data centres could grow from around 1 per cent of total power consumption to between 2 and 6 per cent by 2030.[56]

Box III.G.2
Digital technologies and agrifood systems

Although the agriculture sector still has the lowest levels of digital technology adoption compared to other economic sectors, emerging digital technologies offer great potential to transform agrifood systems going forward. There are strong expectations that these technologies could contribute to increasing agricultural production and productivity, while helping with climate change adaptation and mitigation. New technologies could also support early warning systems on pests and diseases and increase the efficiency of natural resource usage, improving resilience in farming. In addition, digital technologies can also enable small-scale producers to better integrate into markets and reach consumers through e-commerce, thereby increasing efficiency in the design and delivery of agricultural policies.

The adoption of digital technologies, however, can also entail damaging "disruptions" in agrifood systems. They can deepen the digital divide, intensify vertical consolidation, increase energy costs, enhance data asymmetries and generate e-waste. Exclusion of the most vulnerable remains a critical challenge. Only 24 to 37 per cent of small farms have access to 3G or 4G services, compared to almost 80 per cent of large farms. In Africa, only 27 per cent of women have access to the Internet and only 15 per cent of them can afford to use it. As a result, small-scale rural producers, especially women in low- and middle-income countries, have largely been left on the sidelines. The rapid progression of digital technologies also poses significant challenges for institutions in regard to adaptation, and concerted action is required in order for them to develop and benefit society at large.

Source: Adapted from FAO. 2022. The Future of Food and Agriculture: Drivers and Triggers for Transformation.

3.3 Policy options

A country's policy strategies to fully reap the benefits of new and emerging technologies depend on its state of technological development. The technology ladder illustrates the different stages of technology transfer (figure III.G.6), from the importation of foreign technologies to domestic production through imitation, collaborative innovation with foreign firms or fully indigenous inventions.[57] The appropriate policy strategies that a country needs to develop its domestic capabilities differ based on its position on the ladder. For example, countries reliant on technology imports will benefit from policy measures to promote greater adoption and diffusion of these technologies across economic sectors. Countries at the "imitation" and "collaborative innovation" stages will benefit from policies that facilitate the adaption of these technologies to the local context.

Efforts to build technological capabilities are best achieved through a strategic approach, including through sustainable industrial policies. For countries to climb the technology ladder, firms in these countries would need to build increasingly advanced technological capabilities. In this context, the use of sustainable industrial policies can be particularly effective (see chapter II), helping to bring together a range of instruments and interventions that spur the adoption and eventual domestic creation of new technologies.

The use of sustainable industrial policies is particularly important to promote a directed change in the structure of the domestic economy, such as the adoption of green technologies. Recent technological advancements and trends are making it increasingly feasible to decouple economic progress from non-renewable resource usage and greenhouse gas emissions.[58] In this context, there is a strong case for government policies to support the development and adoption of low-carbon and environmentally friendly technologies. These policies differ from traditional industrial policies in several ways, notably in their focus on addressing environmental externalities. As greenhouse gas emissions are grossly underpriced, private returns on investments in green technologies lie significantly below social returns. In addition, the development of new green technologies generates positive spillovers that the inventors cannot fully capture in markets.[59] These factors necessitate interventions, including through policies, incentives, regulations and financing instruments, in order to initiate a shift in the behaviour of producers and consumers and steer investment towards green technologies. Such policies should emphasize inclusiveness to ensure that the technological transition does not exclude vulnerable groups, and also consider related issues such as data ownership and protection.

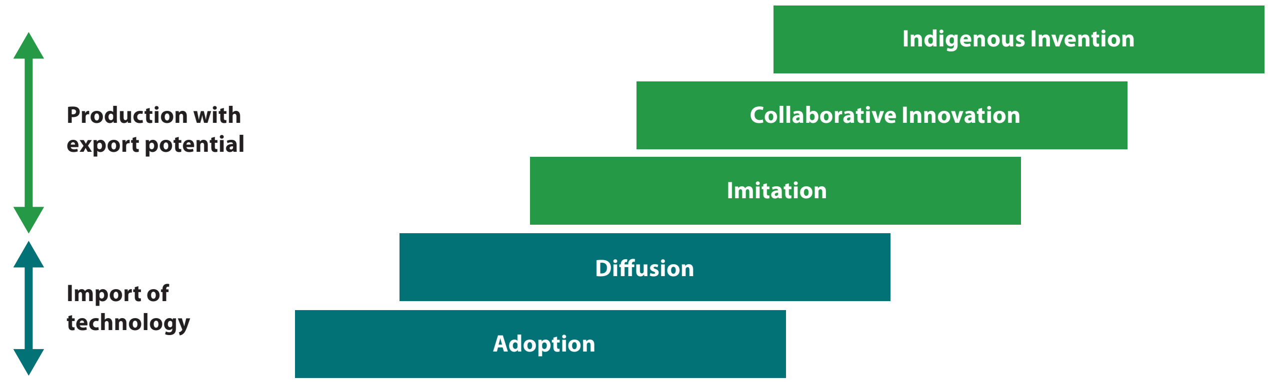
To close large technological gaps between countries, technology transfer is needed. Technological learning and innovation depend on the ability of countries to access, adapt and diffuse technological knowledge. There are many channels through which technology transfer occurs, including trade, licensing, foreign direct investment, movement of workers and managers, inter-university technology collaborations, and open sources of knowledge. The effectiveness of these channels in promoting technology transfer is influenced by several factors, namely: i) the overall enabling environment; ii) economic incentives and support for firms; and iii) international factors.

(i) Enabling environment

Supporting firms in climbing the "technology ladder" requires an overall enabling environment. This includes physical infrastructure, such as transport and energy, digital infrastructure, education and skills, and enabling policy and institutional environments.

- *Physical infrastructure*: Infrastructure gaps remain large in many developing countries, including in the area of affordable connectivity, which continues to be a challenge, particularly in LDCs and remote regions. However, such digital infrastructure is one of the basic preconditions for participating in increasingly digitalized production processes and acquiring relevant technological capabilities. Reliable and affordable access to energy is another critical factor;
- *Human capital* is often found in empirical research to be the most binding constraint for adoption of more advanced technologies; investments in education, skills development, health and related areas

Figure III.G.6
The technology ladder



Source: World Bank Report on Technology Transfer and Innovation for Low-Carbon Development, 2020.

are thus also important. Curricula should be adapted to meet current technology challenges, such as through a focus on digital literacy and basic and more advanced ICT-related skills;

- The broader *policy environment* should be aligned with the objectives of technology adoption and development; in the case of low-carbon technologies, for example, this includes removing carbon subsidies; in an increasingly digitalized economy, data policies become more important to enable domestic actors to unlock the economic opportunities in collecting, sharing and analysing individual data;
- *Competition laws* need to be reinforced, particularly in emerging economies, and adapted to the digital age. Digital markets have created significant challenges for competition policies in recent years, including those related to market structure, the conduct of firms and merger activity. The scalability of digital assets at very low cost has led to highly productive and profitable industry leaders, which in turn has increased market concentration. Given the international nature of many digital firms and the costs of regulatory spillovers, abuses of dominance in digital markets could be more effectively addressed through deeper international cooperation between national competition authorities.[60] The existing framework for combating anti-competitive licensing practices that restrain technology transfer can be deployed more effectively and also serve as a basis for international cooperation;[61]
- *Public investments in R&D* also play an important role in supporting innovation, particularly in countries further up the technology ladder. Building minimum levels of technological and production capabilities typically requires independent R&D efforts as well as access to the global knowledge base. The public research system can contribute to strengthening firms' capabilities to absorb, use and eventually develop digital and other technologies. It can also manage public funded intellectual property to leverage technology diffusion and uptake as well as wider development goal.[62] Governments can also encourage partnerships between existing academic organizations and firms by creating spaces for co-creation and applied research or setting up targeted research institutions that act as incubators for new businesses.

(ii) Economic incentives and support for firms

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

Governments can introduce a range of policy measures directly targeted at building firms' capabilities to adopt new technologies. To support their technological upgrading, direct measures are needed to improve the absorptive capacity of firms, particularly SMEs.[63] Measures to help firms access finance for technology upgrading are crucial, given that financing for such projects in developing countries is limited and costly. These measures could include credit guarantees, publicly backed finance programmes and the provision of grants and loans for firms to purchase new technologies and digital solutions. In addition, governments can expand the provision of business advisory services and technology extension services to boost firms' skills and technological know-how. While business advisory firms aim to promote the use of digital technologies by SMEs in management functions, technology extension services offer on-site assistance to SMEs to facilitate the modernization of production. At the same time, the establishment of technology centres can spur the development or adoption of more sophisticated technologies.

Governments can also introduce targeted incentives or provide dedicated funding for specific technologies and outcomes. Many countries have rolled out initiatives (such as tax rebates or grant funding) to support the development of specific digital technologies. Governments can also steer research and innovation efforts towards augmenting workers' skills and capabilities rather than to labour-saving technologies that replace workers and contribute to wage polarization.

Market competition is an important driver of technological adoption. The World Bank's Firm-level Adoption of Technology survey revealed that more than 40 per cent of firms highlighted competition as the main motivation for upgrading their technologies.[64] Competition from firms in other countries has been shown to incentivize the adoption of new technologies. A study of 12 European countries showed that increased import competition from China drove significant innovation and technological upgrading in firms in these countries.[65] Nevertheless, growing digitalization is reshaping competition dynamics across firms and countries, with markets characterized by strong network effects, substantial economies of scale, disruptive innovations and reliance on large volumes of data. There is a growing need to review existing competition policies given the increasingly complex environment.

(iii) The international dimension—international agreements and institutional environments

How the intellectual property (IP) system most effectively and equitably promotes sustainable development depends on the extent to which it is tailored to a country's stage of development and technological capabilities. IP transactions—notably licenses and transfers of patents and know-how—are an important conduit for technology transfer, and IP rights (IPRs) are generally recognized as investments under international agreements. As legal instruments, IPRs are used to structure partnerships, transactions and production chains, thereby enabling the sharing and dissemination of knowledge and technology. However, domestic governance of the IP system and the exercise of IPRs must be tailored to the context in which they apply, including a country's production structure, its scientific and technological infrastructure, the availability of risk capital, and market size. In broad terms, high-tech IPRs inevitably play a more significant role in economies with a higher level of industrial development and technological innovative capacity (table III.G.2). More inclusive concepts of sustainable innovation and a more even distribution of innovative capacity have recently led to both greater recognition of traditional knowledge systems and the search for more nuanced and better-tailored application of the general principles of IP protection. For instance, a balanced and effective patent system should provide adequate scope for appropriation of due returns for investment in true innovation, while facilitating technology diffusion and ensuring a strong public domain. How this balance is achieved in practice will depend on the economic and technological circumstances—and development priorities—of individual countries, although South-South cooperation may inform the search for such a balance.

Table III.G.2
Industrialization stages and intellectual property rights

Initiation stage	Little or no impact of IP on local innovation. IP may affect access to goods.
Internalization stage	Little impact of IP on local innovation. IP may reduce technological diffusion and affect access to goods.
Generation stage	IP may help to consolidate local innovation strategies. Problems of access remain for part of the population.

Source: Adapted from Correa (2015).[66]

Stronger IPRs can raise the cost of innovation by raising the price of technological inputs. Economies that innovate at the internalization stage (mostly developing countries) or at the stage of initiation (mostly LDCs) may need to ensure that there are sufficient exceptions and limitations—as well as remedies—for anti-competitive licensing and other burdensome constraints on technology diffusion, so that the investment in licensing fees or royalties for technology diffusion are highly productive and beneficial. The World Trade Organization (WTO) TRIPS Agreement recognized the need for maximum flexibility for LDCs in the domestic implementation of laws and regulations in order to enable them to create a sound and viable technological base, and LDCs have no substantive obligations for IP protection until 2033 at the earliest. Developing countries have the scope to deal with resource constraints by applying the TRIPS principle that enforcement of IPRs need not be prioritized over law enforcement generally and running IP offices on a cost-recovery basis, as many developed countries do already.

Policymakers should recognize the complementarities between IPRs, market liberalization and deregulation, technology development policies and competition regimes. The impact of IPRs on technology transfer is highly dependent on country-specific structural conditions such as technological capabilities and institutional quality. Innovation policies in developing economies should allow as much margin as possible to acquire foreign technologies and facilitate the sharing of knowledge vital to sustainable industrialization. For example, the United Nations Economic Commission for Europe (UNECE) Team of Specialists for Innovation and Competitiveness Policies addresses issues related to the creation of a supportive environment for innovation-based development and knowledge-based competitiveness in UNECE Member States. Governments must be aware that adapting their innovation and IP policies to achieve optimal flexibility might be limited by the TRIPS Agreement and, in some cases, by the even higher standards established by free trade agreements. The design of IPR legislation should, however, make full use of the flexibilities left to allow reverse engineering and technological diffusions.

4. Development cooperation and United Nations actions on science, technology and innnovation

The Addis Ababa Action Agenda led to the creation of two mechanisms in 2015/2016 to harness STI for the achievement of the SDGs: **The United Nations Technology Facilitation Mechanism (TFM) and the United Nations Technology Bank for Least Developed Countries (Technology Bank).** The launch of these mechanisms encouraged additional work by United Nations entities on STI. A small selection of these recent activities is featured in this section.

The TFM has brought the United Nations closer to the pulse of scientific and technological progress through a one-UN and multi-stakeholder model that addresses the concerns of all countries. The TFM is where the many activities of the United Nations system and stakeholders come together and forge partnerships. Most importantly, the TFM has become an important entry point not only for organized science and engineering communities but also for individuals. It "facilitates" collaboration and partnerships—for sharing information, experiences, good practices and policy advice among relevant stakeholders. This includes Member States, civil society, the private sector, scientific and technological communities, United Nations entities, and others. It also supports technology transfer through knowledge-sharing, capacity-building and the matching of technology providers with users.

Participation in the TFM has increased. As of February 2023, the Inter-agency Task Team on Science, Technology, and Innovation for the SDGs (IATT) brings together more than 100 experts from 48 United Nations entities who work together in 10 dedicated work streams. These range from a pilot programme and partnership on national STI4SDG roadmaps, to policy analysis and research work on emerging science and tech futures as well as awareness-raising on gender in STI. The IATT also mobilizes science-policy briefs and perspectives from experts, enabling them to propose issues to be put on the United Nations agenda. The Secretary-General's 10-Member-Group of High-level Representatives of Civil Society, Private Sector and Scientific Community to support the TFM has not only mobilized the engagement of many experts but has emerged as a hub for science and technology advice in the United Nations system. The Multi-Stakeholder Forum on Science, Technology and Innovation for the SDGs brings together governments with thousands of science and technology stakeholders every year. Many of them are new to the United Nations. They range from young, engaged scientists to start-up entrepreneurs and world-renowned experts. Finally, the TFM online platform "2030 Connect" provides one-stop-shop access to technology and knowledge databases of an increasing number of United Nations and other international organizations.

The TFM and its STI Forum have facilitated discussions on sensitive political issues and opened new avenues for all Member States, including those that may feel they are being left behind in the latest scientific-technological revolution. The TFM and STI Forum are among the most prominent and inclusive United Nations entry points for engagement by scientists, engineers and tech entrepreneurs. One key insight from past STI Forum discussions has been that new technologies—biotech, AI and nanotech—are vital for all kinds of SDG breakthroughs. They progress at accelerated, exponential rates—so rapid that it remains unclear whether traditional institutions and regulators are able to cope. The STI Forum is a United Nations space enabling discussion of these issues.

The Technology Bank is mandated to strengthen the STI capacity of LDCs. The Technology Bank continues to work towards promoting and facilitating the identification, utilization, access to and transfer of appropriate technologies to LDCs. In 2022, the Technology Bank completed six technology needs assessments—in Bangladesh, Benin, Djibouti, Kiribati, Mozambique and Sierra Leone—while implementing other programmes.

The Global Environment Facility has played a vital role in providing developing countries with financial support to address climate change. Since its inception in 1991, the Global Environment Facility has allocated more than $22 billion in grants and blended finance and mobilized $120 billion in co-financing for more than 5,000 projects in 170 countries, supplemented by 27,000 community-led initiatives through its Small Grants Programme.

The Climate Technology Centre and Network promotes the accelerated transfer of environmentally sound technologies for low-carbon and climate resilient development. In 2010, the Technology Mechanism of the United Nations Framework Convention on Climate Change was established to support the development and transfer of climate-compatible technologies to developing countries. The Climate Technology Centre and Network, its implementation arm, provides technical assistance with the help of a global network of climate technology experts that design and implement solutions tailored to local needs. This includes: (1) technical assessments, including on technology needs, barriers and efficiency; (2) technical support for planning documents such as policies, strategies, roadmaps and action plans, regulations and legal measures; (3) training; (4) tools and methodologies; and (5) implementation plans. Technical assistance is provided free of charge to developing countries (with a value of up to $250,000) for a broad range of climate adaptation and mitigation technologies. Assistance can be provided for all stages of the technology cycle.

International cooperation helps to raise awareness in developing countries through sharing lessons learned and best practices, while drawing attention to new and emerging technologies. The Commission on Science and Technology for Development brings together Member States in information-sharing and intergovernmental discussions on issues related to the adoption of frontier technologies for sustainable development. In recent years, the Commission has assessed the impact of various STI trends, including renewable energy, Industry 4.0, space technologies and blockchain technologies. At the same time, the World Summit on the Information Society Forum facilitates the sharing of information and knowledge about the social, economic, cultural and environmental impacts of ICT. The Forum is witnessing an increased number of sessions for sharing national strategies, policies and initiatives on clean technologies, environment-related policies and strategies, and the role of ICT in advancing competitiveness and increasing productivity.

The United Nations system undertakes a range of programmes for building the capabilities of countries to develop and deploy technologies for more sustainable production and consumption. For example, the International Trade Centre's Netherlands Trust Fund V Programme has delivered a Greening ICT training to 80 technology start-ups and IT companies in Africa, encompassing the areas of energy efficiency, electronic waste management, and ICT sustainability standards. ITU has supported efforts towards achieving a circular economy for electronics, including through expertise on e-waste data, national e-waste policies and regulation (including in Botswana, the Dominican Republic and Namibia). The United Nations Environment Programme has implemented capacity-building programmes on green technology through the Climate and Clean Air Coalition. The United Nations Industrial Development Organization has rolled out the "SWITCH to circular economy value chains" project, which aims to support enterprises in adopting circular economy practices. The United Nations Economic and Social Commission for Western Asia has supported implementation of national consultation sessions on resilience and sustainability of the agriculture sector in the Arab region. The UNECE Team of Specialists on ESG Traceability of Sustainable Value Chains in the Circular Economy is developing holistic approaches for fostering ESG improvements throughout global supply chains. UNECE has also launched Circular STEP—a platform for policy dialogue on the circular economy.[67] The International Atomic Energy Agency (IAEA) has assisted countries in using nuclear technologies for development, including in the agrifood systems and energy sectors (box III.G.3).

Box III.G.3
The potential contributions of nuclear technologies to sustainable development

Nuclear science, technology and innovation can contribute to addressing climate change and identifying solutions in multiple interrelated sectors such as energy, food and agriculture, water, industry, human health, ecosystems and the environment. The IAEA supports countries in building capacities to apply nuclear technologies and techniques in several areas, including agrifood systems and energy.

Agrifood systems: Nuclear techniques such as mutation breeding are used to develop improved drought- and heat-tolerant crop varieties as well as enhance existing genetic resistance in crops towards insect pests and diseases. Nuclear techniques are also used to strengthen post-harvest food safety and trade, reduce food waste and monitor residues and contaminants in food.

Nuclear technologies also contribute to the development of climate-smart agricultural practices. These technologies are used to monitor agrochemical inputs to improve food safety, and to support the development of innovative land and water management, with improved soil and nutrient management practices and efficiency of water usage.

Energy for Net-Zero: Nuclear power can contribute to decarbonizing not only the power sector but also other sectors, including the building, industry and transport sectors, through applications such as district heating, desalination, industry process heat and hydrogen production. With its dispatchability, flexibility and ability to provide grid services, including stability, nuclear power can allow high penetration of renewables in net zero transitions.

The IAEA assists countries that opt for nuclear energy to meet their climate objectives through support for countries' efforts in building new nuclear power plants, extending the operational lifetimes of existing ones and through capacity-building in energy planning. In the Atoms4NetZero initiative, the IAEA will work in partnership with Member States to model and measure the contribution of nuclear power to their net zero energy transitions and assess the potential of nuclear to be used beyond the grid—for example, to produce hydrogen or for desalination.

Source: IAEA.

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