CHAPTER IV

TWIN TRANSITIONS FOR GLOBAL VALUE CHAINS – GREEN AND DIGITAL

The digital and the green transformations can be twins if there are strong enough policy responses

The digital and green transformations can support each other

Capturing data using online-connected sensors and GPS can reduce carbon emissions

Smart manufacturing consumes less energy

Voluntary sustainability standards help upgrading value chains

Developing economies have to close the gap to take advantage of the twin transition

The countries best placed to move to smart production are those with stronger manufacturing industries and higher levels of skill

More than 90 per cent of all patenting in industry 4.0 technologies are from high-income countries and China

The top ten front runners in emerging digital technologies are all high-income countries and China

The government, private sector, and the international community can act to open windows of opportunity

Aligning digital and environmental strategies

Developing the digital infrastructure and setting regulations

International cooperation supports this process by facilitating access to finance and external knowledge

This chapter examines the options for latecomer countries in greening and digitalizing, and the opportunities to benefit from these twin transitions in global value chains (GVCs). These two processes have largely developed in parallel but have become increasingly intertwined. Technologies such as AI, cloud computing, and IoT can also help the economies become greener – while also accelerating progress for all 17 SDGs.

Since the early 1990s, GVCs have become the cornerstone of the world economic system. Through GVCs, firms specialize in specific tasks and break up the production process across different countries. Today, about two-thirds of international trade of services and goods comprises transactions within supply chains. These are often sales of intermediate goods – of parts, components and accessories used to produce final products.[1] Exports of such goods declined in 2020 because of the COVID-19 pandemic but rose again in 2021, surpassing the pre-pandemic level.[2] COVID-19 broke many chains, encouraging companies to reconfigure and diversify to be more resilient in the face of pandemics and other disruptions, but GVCs will be important components of world trade for some time to come.[3]

Many emerging and developing countries have been able to use GVCs based on their specific advantages and specialization in tasks rather than on final goods. But this kind of production is unlikely to stimulate sustainable growth: if developing countries are to gather the full benefits of GVCs they will need to move up the value-added ladders to more sophisticated manufacturing and services.

As they upgrade, companies and countries should also embed social and environment values. Social upgrading refers to improving the rights and entitlements of workers and their employment. Environmental upgrading refers to a firm’s ecological footprint, including its use of natural resources, its emission of greenhouse gases and any destruction of biodiversity.[4] These improvements are increasingly being demanded by consumers who are seeking more ethical products, and by lead firms and global buyers, and governments. Changes are also being required by social and environmental standards and associated patterns of upgrading and downgrading across global supply bases.

This chapter focuses on technological and environmental upgrading, and on how GVCs can become greener by switching to digital frontier technologies associated with smart manufacturing – often referred to as Industry 4.0. Across the global South, most countries have operating within Industry 3.0, but have yet to adopt smart manufacturing and services or the more advanced methods of data processing and analysis. Indeed, many firms in these countries have yet to upgrade to the previous generation of manufacturing or service technologies. At present only a few countries are using advanced digital technologies, and even fewer are designing and producing them.[5]

A. THE GREENING OF GVCS

GVCs can become greener through two main routes. The first is by manufacturing the goods used for green production, such as, solar PV panels and wind turbines.[6] The second is by greening traditional manufacturing industries, such as food, garments and textiles, leather and shoes, and furniture – all of which are important for low- and middle-income countries.

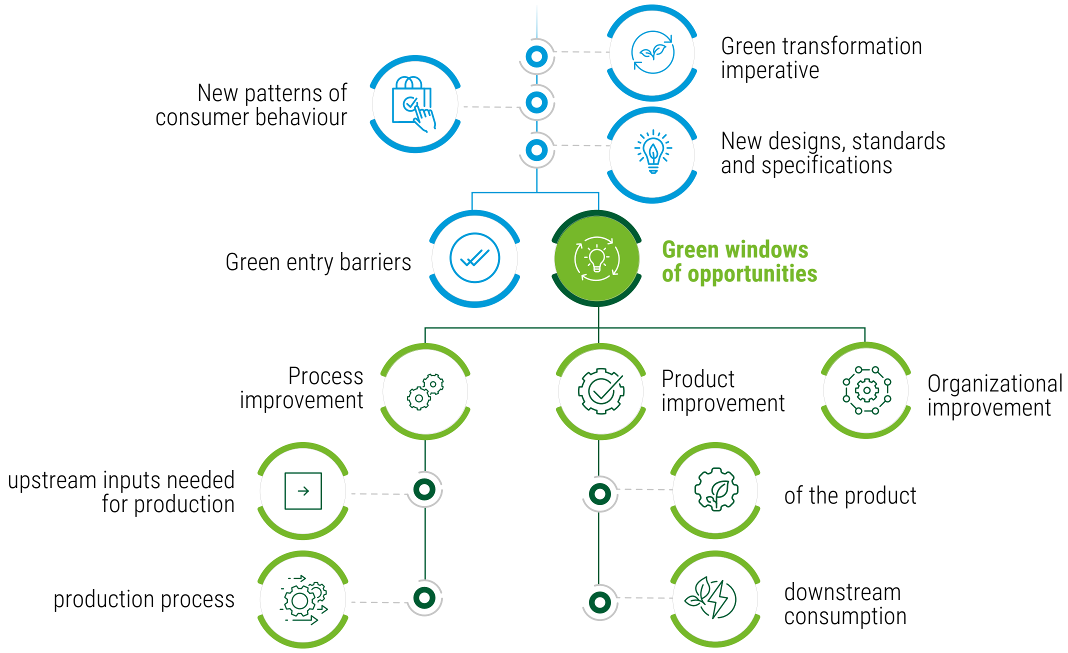
1. ENVIRONMENTAL UPGRADING

Environmental upgrading can be defined as any change that reduces a firm’s ecological footprint through lower greenhouse gas emissions, low natural resource use or less impact on biodiversity.[7] As a result, the process can also use less energy or materials per unit of output. Or the upgrading can be through product improvements – removing harmful chemicals, for example, and making the products more recyclable and part of the circular economy. Or the upgrade could be organizational, such as the introduction of environmental management systems.[8]

Much of the impetus is coming from consumers. Informed by NGOs, and by the media, including social media. Consumers are increasingly seeking products and processes that have lower environmental footprints. They are also considering whole product lifecycles, starting from the sourcing of materials such as rare earth metals for electric vehicles and wind turbines,[9] through the management of chemicals in the production of solar PV panels, and then on to what happens after decommissioning, with the reuse of materials.[10] Customers, investors, and policymakers also want greater disclosure and transparency. At the same time, companies see opportunities not only to respond to consumer demand but also to make savings, through more efficient manufacturing and better use of materials.

The processes can be considered as a series of steps, starting from the initial demand, through new designs and product improvements (Figure IV-1).

Figure IV 1
Steps for greening GVCs



Source: UNCTAD.

These changes are transmitted along value chains through new designs, standards and specifications. Usually, the new designs start in countries that pioneer environmentally benign products, processes and services – 'green lead markets'.[11] These countries introduce new private standards, defined and enforced by lead firms. They also internalize several public environmental regulations and semi-private environmental certifications, such as the Technical Regulations (TRs) Certification (e.g., Round Table on Responsible Soy), which, beyond the core private sector firms and organizations, includes authorities and governmental agencies and public donors. The demands for sustainability have implications for the entire value chain, including its governance – how some firms in the chain set and enforce the parameters under which others in the chain operate.

The process is rarely smooth. Higher standards can also present barriers. Some suppliers may be unable to invest in new processes and thus get squeezed out of the value chain.[12] But for other enterprises the new standards signal green windows of opportunity, providing they can realign accordingly.[13] Well-functioning production and innovation systems depend on deeply embedded suppliers who are also flexible.[14]

This chapter focuses on four types of digitally driven upgrades:

- *In product design* – Upgrading the product, substituting environmentally harmful components and products, designing recycled products, designing for durability.
- *In production inputs* – Changing energy sources, substituting energy-intensive materials or scarce natural resources and removing toxic inputs.

- *In production process* – Reducing waste and energy consumption from the production processes and optimizing material flows.
- *In consumption* – Including use, recycling and re-use of waste.

2. THE TWIN TRANSITIONS

The environmental and digital transformations have largely developed in parallel, with their own trajectories and separate drivers and policy domains. However, this is now beginning to change as they merge into twin transitions with many functional synergies. This broader potential of digital technologies was also part of the Sustainable Development Goals which indicated that digitization could enable the changes needed for a just sustainable transition (Box IV-1).[15]

Box IV 1
The impact of Industry 4.0 technologies in global value chains

Digitalization is expected to have wide-ranging effects in manufacturing in GVCs.[16] It has been argued that digitalization will put developing countries at a disadvantage since it reduces the need for labour, and thus reduces the comparative advantage of many developing countries of offering low labour costs.

Companies may thus reshore some activities towards high-income economies.[17] However, reshoring remains a rare phenomenon.[18] In the European Union, for example, data from 2,500 firms in eight countries indicates that the phenomenon has been modest and varies from one industry to another, and that the main driver has been flexibility in logistics rather than the evening-out of labour costs.[19]

The impact of Industry 4.0 on GVCs could also depend on the technology. Robots and computerized manufacturing could reduce the advantage of producing in low-labour-cost countries. Similarly, 3D printing could shorten GVCs and enable firms to keep production closer to markets, as happened during the COVID-19 pandemic when 3D printing was used to remedy shortages in medical supplies. 3D printing can democratize manufacturing allowing companies in latecomer countries to engage in manufacturing without large investments, opening opportunities for distributed local production processes,[20] but it can also allow firms from high-income countries to produce closer to their customers.[21]

The new technologies can also present new barriers to entry in GVCs in terms of know-how, skilled human resources, and capital investments.[22] The IoT, for example, could make manufacturing less reliant on low-skilled labour and more dependent on the availability of engineers, programmers, and other specialized professions, which are in short supply in many latecomer countries.[23]

Nevertheless, GVCs do present channels through which developing countries can better engaged with digital technologies. A UNIDO study in five ‘latecomer’ countries found that, although less than 5 per cent of the surveyed firms were aware of Industry 4.0 technologies, firms could still integrate the technologies into their manufacturing processes and become more productive.[24]

Digital technologies such as IoT and AI could also encourage more SMEs from developing countries to participate in GVCs by tracking shipments and inventory bridging and thus reducing trade costs.[25] AI can help firms find the fastest, cheapest, and most sustainable routes for shipping goods around the world.

Industry 4.0 technologies could held decentralize advanced activities across regional production networks, allowing more peripheral locations to house activities such as engineering, design, and software development. This can help them better serve regional markets.[26] For example, Cloudfactory, a United States company offering data processing services for AI and automation, has opened subsidiaries in Nepal and Kenya. The company has sliced up its activities, retaining the more advanced parts of the value chain in the United States headquarters, while employing staff in Nepal and Kenya for data input, quality control and processing – offering new opportunities for, mainly young, well-trained workers.[27]

Source: UNCTAD.

Industry 4.0 technologies can enhance the productivity, improve safety, and decrease the environmental impacts (Box IV-2). They can reduce the carbon footprint of current production and consumption modes – facilitating the introduction of new green technologies and eco-products and enhancing the diffusion of business models based on circular economies. Nevertheless, digital technologies may also cause further environmental degradation due to the use of rare materials in their production, for example, and high energy consumption entailed in their use.

Box IV 2
Industry 4.0 technologies in mining

Mining might represent a challenge for frontier technologies. It is a relatively difficult sector to develop and apply technologies like IoT due to its environment, which involves dust, high humidity, and often isolated locations lacking connectivity.[28] This does not mean, however, that the sector must be stuck in the past with traditional methods. In fact, actors in the industry note that mining is going through the beginning of a profound digital transformation.[29]

One example is the Syama mine in Mali, which is a purpose-built and fully automated mine. It employs a fibre-optic network designed to control and monitor activities from above-ground centres, incorporating an automated haulage system, automated rehandle level, and digitalisation.[30] This is expected to generate a cut in costs by around 30 per cent and improve efficiency and productivity as the machines can operate 22 hours a day without losing time for shift changes.[31]

However, taking advantage of the opportunities available by Industry 4.0 technologies involves policy efforts. There must be investments in infrastructure to support the digitalisation of mines, as well as the provision of education and training to mitigate the impact on low-skilled labour. Policies and regulations are an important incentive for innovations in the sector through, for instance, pushing for stricter environmental regulations.[32]

Source: UNCTAD.

The more advanced technologies can be considered in two categories (Table IV-1):

1. *Smart manufacturing and service technologies* – leading to automation and decentralization of tasks and including advanced robotics, 3D-printing, wireless technologies, and sensors.
2. *Data processing technologies* – allowing interconnection and data exchange, including big data, blockchain, cloud computing, and AI.[33] What makes these technologies novel is the integration of hardware, software, and connectivity in complex production systems.[34]

Table IV 1
Selected industry 4.0 technologies in manufacturing

Technology		Description
Smart manufacturing and service technologies		
Industrial robots		Robots are programmable machines that carry out actions and interact with the environment via sensors and actuators, either autonomously or semi-autonomously. Industrial robots usually replace workers, automating almost entirely the processes on the factory floor. Examples are spot welding robots used in the auto industry.
Cobots		Cobots are robots that collaborate with humans. They are easily re-programable, for example, by a worker guiding the arm of the cobot through a new path. They can be used in machine tools in a manufacturing plant, packaging and palletizing.
3D printing		3D printing, also known as additive manufacturing, produces three-dimensional objects based on digital information. 3D printing can create complex objects, with little waste. 3D printers are used for prototyping and also for final production in manufacturing.
Internet of Things (IoT)	IoT refers to internet-enabled physical devices that collect, share and act based on data. The IoT is vast; typical fields include wearable devices, smart homes, smart healthcare, smart cities and industrial automation. In manufacturing, IoT connects traditional machinery and tools with actuators and sensors.	
Actuators		An actuator is a component of a machine that is responsible for moving and controlling a mechanism or system. It could be pneumatic, hydraulic, electric, thermal or magnetic. Actuators could, for example, measure heat or motion to determine the resulting action in the machine.
Sensors		Sensors detect external and internal conditions of equipment and products and send that information through the digital network. They can measure temperature, humidity, pressure, proximity and level, and visual and infrared rays.
Data processing technologies		
Big data	Big data refers to datasets whose size or type is beyond the ability of traditional databases to capture, manage and process. Big data also refers to the used of traditionally inaccessible or unusable data for making decisions.	
Artificial intelligence (AI)	AI is normally defined as the capability of a machine to engage in cognitive activities typically performed by the human brain. AI is already widely used for applications that focus on narrow tasks, such as recommending what to buy online, spotting spam or detecting credit card fraud.	

Source: UNCTAD based on UNCTAD (2022d).

Smart manufacturing and service technologies

Digital technologies can upgrade GVCs in numerous ways:

Monitoring standards – Standard-setting organizations can use new technologies for monitoring food, forestry and fisheries.[35] Instead of making annual field audits, officials can install fixed or mobile sensors to collect real-time data. Embedded in harvesting and logging equipment, for example, the sensors can upload to satellites data on tree species and biodiversity – and help detect illegal logging and fishing. International organizations such as FAO and the World Bank are now adopting these methods for monitoring environmental standards.

Logistics – Data collected from online-connected sensors, and from GPS tracking systems, can optimize logistics and significantly reduce carbon emissions.[36]

Operating efficiency – Smart manufacturing consumes less energy.[37] One plastics multinational, for example, has used energy sensors and IoT to reduce the power consumption in one of its plants by around 40 per cent, saving over $200,000 a year in energy costs.[38] Similarly, a smartphone manufacturer in China has optimized the operation of robots to increase productivity by 50 per cent.[39]

Better design – 3D-printing has been shown to reduce the weight of aircraft parts by 50 per cent and that of the aircraft by 4 to 7 per cent, with an estimated six per cent drop in fuel consumption.[40] This technology could thus significantly reduce carbon emissions from air travel.[41]

Data processing technologies

The use of big data analytics, cloud computing, artificial intelligence and blockchain technology can aid the reduction of environmental impacts in the production, processes or practices involved in the inputs needed for production:

Artificial intelligence – AI is important for environmental domains such as energy, production and natural resource management.[42] For electricity, for example, firms are using ‘smart grids’, to optimize green energy use – as well as smart meters, and other equipment. In agriculture, AI can be used for intelligent food logistics, using sensors and other technologies to plan shipping and delivery of perishable goods and for monitoring the state of the cargo. Lead firms are increasingly adopting sustainability tools to cut operational costs, increase product value, and coordinate GVCs. Certifications, codes of conduct, supply chain reporting, lifecycle assessments, supplier audits, smart packaging, and eco-efficiency programs may all be aided by AI.

Blockchain – Blockchain is a distributed verification system, in which the authenticity of a transaction or item is not provided by one institution, such as a bank, but is securely distributed and encrypted across a network of computers. Blockchain can be used, for example, to provide authentic information on the origin and sustainability of products,[43] Similarly, blockchains can be used for supply chain management – systems such as Echochain, ElectricChain, and Suncontract[44] are tracking faulty products or components, helping reduce the number of recalls and their environmental impact. [45] Blockchain can enhance sustainability; the Supply Chain Environmental Analysis Tool for example, traces the carbon footprint of products, and the Endorsement of the Forestry Certification tool can indicate whether wood is sustainably sourced. In addition, blockchains have downstream implications, as with the RecycleToCoin system that enables people to return plastic containers for a financial reward. Nonetheless, such initiatives must also ensure that recyclers have the appropriate equipment and work conditions since they deal with potentially hazardous substances, making them vulnerable to a myriad of health risks.[46]

However, as in other areas, there is always the risk of greenwashing, since AI does not always enhance sustainability to the extent that companies claim.[47] Firm managers may overstate the impact of AI in order to boost brand and stock values.[48]

Greener relationships along the value chain

In assembly industries, there are many opportunities along the value chains to reduce materials, water and energy consumption, pollution emission, and waste reduction.[49] How this happens and who takes the initiative will depend on the nature of the relationships between each link in the chain – on the type of governance (Table IV-2). Governance can be classified as 'relational', if buyers and suppliers have reciprocal trust and long-term relationships and are interacting frequently to share information. Or governance can be 'captive' if there is a degree of monitoring and control by lead fires over small suppliers who are transactionally dependent, making it difficult to switch. In this case buyer firms may pay for upgrading service providers, both for reputational and cost-saving reasons.

Table IV 2
Five types of GVC governance

Type	Description
Market	This type has a low degree of explicit coordination and power asymmetry. Market linkages do not have to be completely transitory, as is typical of spot markets; they can persist over time, with repeat transactions. The essential point is that the costs of switching to new partners are low for both parties.
Modular	Typically, suppliers in modular value chains make products to a customer's specifications, which may be more or less detailed. Often, 'turn-key services' suppliers take full responsibility for competencies surrounding process technology, use generic machinery that limits transaction-specific investments, and make capital outlays for components and materials on behalf of customers.
Relational	In these GVCs, interactions between buyers and sellers are complex, which often creates mutual dependence and high levels of asset specificity. This may be managed through reputation or more trust-based ties. Spatial proximity may support relational value chain linkages, but trust and reputation might well function in spatially dispersed networks where relationships are built up over time. This type has an intermediate degree of explicit coordination and power asymmetry.
Captive	In these networks, small suppliers are transactionally dependent on much larger buyers. Suppliers face significant switching costs and are, therefore, 'captive'. Such networks typically have a high degree of monitoring and control by a lead firm.
Hierarchy	This governance form involves vertical integration. The dominant form of governance is managerial control, flowing from managers to subordinates, or from headquarters to subsidiaries and affiliates. This type has a high degree of explicit coordination and power asymmetry.

Source: UNCTAD adapted from Gereffi et (2005).

In Sri Lanka, for example, lead firms use environmental standards as an element of chain coordination.[50] In this case, supplier firms comply with environmental standards to increase their competitiveness.[51] But not all firms may agree. In the leather industry, for example, producers believe that processing with chrome has the lowest environmental impacts along the entire chain, while buyers for brands believe that processing without chrome is better for their image.[52]

Another example is the maritime industry where a simple option is to reduce vessel speed since emissions are lower for slow ocean-going vessels[53] or to create smart ports (Box IV-3).[54] Alliances with cargo-owners and regulators can also enable technology for onboard monitoring.[55] This is in line with the international maritime organisation's measures to cut emissions from ships and reach half of 2008 emissions' level by 2050.[56]

Box IV 3
The strategic importance of sustainable smart ports

Over 80 per cent of global merchandise trade by volume, and more than 70 per cent by value, is seaborne. International shipping and ports provide crucial linkages in global supply chains and are essential for the ability of all countries to access global markets. Ports are critical infrastructure assets that serve as catalysts of economic growth and development.

UNCTAD has a project to raise awareness among ports and national authorities about the strategic importance of "Sustainable Smart Ports" (SSP) and in the importance of everyone competing on a level playing field.[57] Sustainable Smart Ports take advantage of the new data environments and the energy transition of the maritime sector, artificial intelligence and green technology-based solutions to enhance port operational efficiency. They also promote energy efficiency and clean/renewable energy sustainability, as well as tap into the possibility of producing clean/renewable-energy production and distribution.

Funded by the United Nations Development Account, this $600,000, three-year project started in 2022 and will support port authorities in Morocco, Ghana and Mauritius to assess the SSP status of their ports and identify and implement key priority actions.

Source: UNCTAD.

Supplier squeeze

Lead firms may, however, push the costs of sustainability compliance onto their suppliers, as has happened in wine and coffee sectors – resulting in 'supplier squeeze'.[58] Higher demands may also raise the barriers for entry and thus keep out smaller producers and deepen imbalances of power between firms in the North and South. This is because sustainability measures along GVCs have allowed lead firms, which are usually from the Global North, to capture new rents, reinforcing imbalances of power between firms in the Global North and the Global South.

If buyers are to demand higher standards, they will need to support suppliers. European buyers of olive oil from Tunisia, for example, tried to impose standards but due to a lack of financial and technical assistance, the extent of environmental upgrading of suppliers remained limited.[59]

Similarly, in the apparel industry in Pakistan, suppliers see environmental upgrading mainly as a cost, and a necessary 'entry ticket' for GVCs, and will need to invest new technology, certifications, system modifications and skills development, for which they are not compensated.[60]

Voluntary sustainability standards

Upgrading value chains can be based on voluntary sustainability standards (VSS). The United Nations Forum on Sustainability Standards (UNFSS) defines VSS as "standards specifying requirements that producers, traders, manufacturers, retailers or service providers may be asked to meet, relating to a wide range of sustainability metrics, including respect for basic human rights, worker health and safety, the environmental impacts of production, community relations, land-use planning and others".[61] VSS aims to promote sustainability mainly through collaboration among NGOs, industry groups or multi-stakeholder groups. By 2020, there were 150 VSS in agriculture and around 30 for mining and industrial products

VSS are gaining ground among diversified, export-oriented economies. Viet Nam, Indonesia and India score fairly high on VSS adoption, as do Ethiopia and the United Republic of Tanzania whose coffee exports are certified to meet multiple standards.[62]

By 2020, the number of voluntary sustainability standards range from 150 in agriculture to around 30 in mining and industrial products (See Box IV-4 for examples from various sectors). In agriculture, 14 VSS organizations cover eight agricultural commodities globally – bananas, cocoa, coffee, cotton, oil palm, soybeans, sugarcane, tea and forestry products.[63] In 2019, those standards certified a minimum of 20 million hectares of the eight agricultural commodities, around 8 per cent of the global area.[64] For bananas, certifications are concentrated in Colombia, Costa Rica, the Dominican Republic, Ecuador and Honduras; for cocoa, Côte d'Ivoire; for coffee, Brazil, Central America and Colombia; for palm oil, Indonesia and Malaysia; for soybeans, Argentina and Brazil; and for sugarcane Brazil.[65]

For textiles and clothing there are two main standards.[66] The Global Organic Textile Standard is recognized as the world's leading processing standard for organic fibres, including ecological and social criteria, independent certification of the entire supply chain.[67] The Fairtrade Textile Standard has been produced by Fairtrade International which supports small producer organizations and agricultural workers in developing countries.[68]

Box IV 4

Examples of voluntary sustainability standards

Manufacturing: In textiles: Organic Content Standard (OCS), the Global Organic Textile Standard (GOTS) and the Fairtrade Textile Standard. GOTS certified final products may include fibre products, yarns, fabrics, clothes, home textiles, mattresses, personal hygiene products, and food contact textiles.

Other sustainability standards for manufactured products include: ABNT Ecolabel, ARSO - Agriculture, ASEAN Guidelines on Promoting Responsible Investment in Food, Agriculture and Forestry, BRCGS Food Safety, Carbon Trust Product Footprint Certification, East African organic products standard (EAOPS), EcoVadis, Ethical Trading Initiative (ETI), Fair Labor Association, GreenCo, Recognised - Environmental Credentials Scheme, Global Reporting Initiative (GRI), ZNU standard, and the Climate, Community & Biodiversity (CCB) Standards. CCBs are used to identify projects that simultaneously address climate change, support local communities and smallholders, and conserve biodiversity. As of May 2017, 102 projects in 32 countries have been validated by the CCB Standards. The preponderance of projects is in tropical developing countries, particularly in Africa.[69]

Forestry: Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) are the two leading VSS at the global level. In 2019, PEFC and FSC certified more than 433.5 million hectares of forest, representing 10.7 per cent of the global forest area.[70]

Fishing: The Marine Stewardship Council (MSC) is an international non-profit organisation, which aims to promote sustainable fish stocks, minimizing environmental impact and ensuring effective fisheries management through the MSC Fisheries Standard. Developing world fisheries account for around 8 per cent of the total of MSC certified fisheries and 11 per cent of fisheries. More than 40 developing world fisheries have had pre-assessment and are engaging in a Fishery Improvement Project with partners.[71]

Mining: The main sustainability standards include the Alliance for Responsible Mining (ARM), Fairtrade International (FLO), Fairmined Standard, Fair Stone, IGEP, Responsible Jewellery Council (RJC), Social Accountability International, the Aluminium Stewardship Initiative Performance Standard, SGE 21, XertifiX. Established in 2004, ARM is a leading global expert which aims to transform the mining sector into a socially and environmentally responsible activity, through developing standards and certification systems for responsible artisanal and small-scale mining and facilitate the access of certified metals to fair supply.[72] Likewise, the Fairtrade Standard for Gold and Associated Precious Metals for Artisanal and Small-Scale Mining makes changes to the conventional trading system. It aims to improve small producers‘ social and economic well-being and enhance environmental sustainability.[73]

Energy products: Sustainability standards include the Alliance for Water Stewardship, Carbon Trust Product Footprint Certification, EO100TM Standard for Responsible Energy Development, Green-e, ISCC Plus, Lasting Initiative for Earth Certification, TerraChoic, Verified Carbon Standard (VCS), WFTO Guarantee System, SOCIALCARBON® Standard. To illustrate, the VCS Program provides the standard and framework for independent validation of projects and programmes, and verification of GHG emission reductions and removals.[74] The Round Table on Responsible Soy (RTRS) is a civil organization that promotes socially equitable, economically feasible and environmentally sound soy production. The RTRS Standard operates in China, India Argentina, Brazil, Paraguay and Uruguay.[75]

Livestock and tourism: VSS include East African organic products standard, VietFarm, and the Wildlife Friendly Enterprise Network (WFEN). The WFEN is a global community which unites conservationists, businesses, artisans, producers and harvesters. Certified Wildlife Friendly enterprises protect threatened and endangered species in Asia, Africa, Europe and the Americas, conserve over 13 million hectares of diverse wetland, forest and grasslands, and benefit over 200,000 people who coexist with wildlife.[76]

Source: UNCTAD.

3. SLOW DIFFUSION OF DIGITAL TECHNOLOGIES IN LATECOMER COUNTRIES

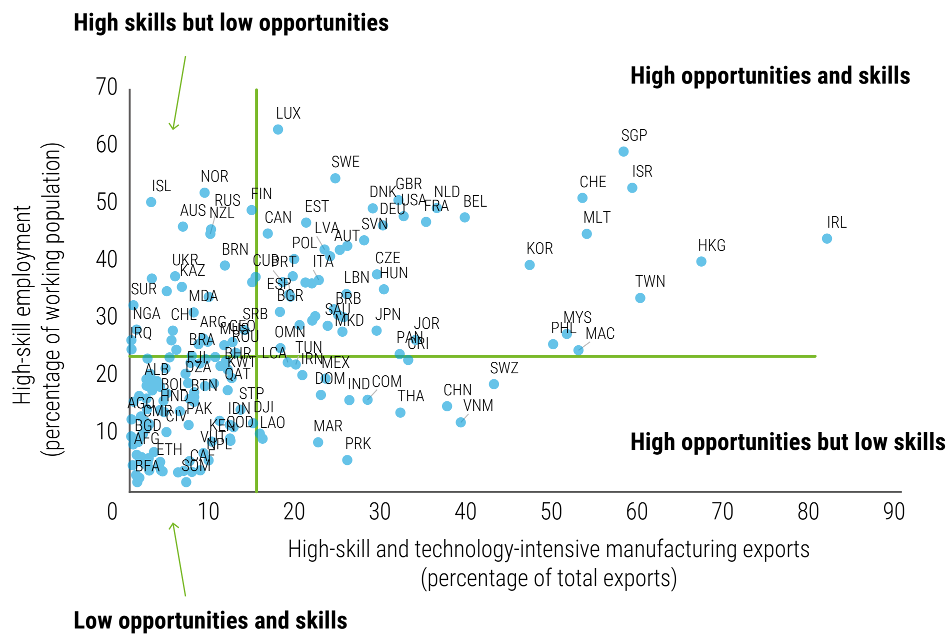
Thus far, Industry 4.0 technologies are mostly produced and adopted in a few leading economies.[77] More than 90 per cent of all patenting is in ten countries, all high-income except for China.[78] For exports the top ten countries, again including China, account for 70 per cent of the global market. Concentration is lower for imports: the top ten countries account for only 46 per cent of global imports of these technologies and include China, Mexico, India and Türkiye.[79]

For emerging digital technologies, UNIDO has identified the front-runner countries.[80] The top ten, are all high-income countries except for China. After these are 40 countries: 23 producer economies, among which there are Brazil and India; and 17 user economies comprising Algeria, Argentina, Bangladesh, Colombia, Indonesia, the Islamic Republic of Iran, Malaysia, Mexico, South Africa, Thailand, Türkiye and Viet Nam. The remaining countries show low to no activity, but all countries will be affected by the adoption of digital technologies in the more advanced countries.[81]

The adoption of digital technologies differs not just by country but also by sector and industry. As might be expected, the computer and machinery industry leads the way, making the greatest use of cloud computing and 3D printing technologies, while the transport equipment industry leads for the adoption of industrial robots.[82] In Morocco for example, the automotive industry is making more use of such technology than the garment industry.[83]

The countries best placed to move to smart production are those with stronger manufacturing industries and higher levels of skill. Figure IV-2 gives an indication of readiness, showing the high-skill and technology-intensive manufacturing exports as a percentage of total exports, and high-skill employment as a percentage of the working population. It is important to emphasise that the figure illustrates a simplified version of the analysis regarding the relationship between industry 4.0 benefits and manufacturing and labour skill levels.

Figure IV 2
Readiness to benefit from the diffusion of Industry 4.0



Source: UNCTAD (2022d: 18).
Note: The solid lines represent the unweighted global averages under these two indicators. Data labels use International Organization for Standardization economy codes.

The lines represent the unweighted global averages in these two indicators, segmenting the countries into four groups. According to these estimations, clustered in the top-right quadrant are the countries best placed, which are the United States and many countries in Europe, and in East and South-East Asia. To the bottom are countries which import high-tech goods, but lack the skills needed for a widespread diffusion of Industry 4.0. These include China, India, Mexico, Thailand, and Viet Nam. A third group has the necessary workforce but not the companies to take advantage of them, which may make it difficult to broaden beyond pockets of technology-intensive manufacturing. This includes many countries that rely heavily on commodity exports. such as Argentina, Brazil, Chile, Kazakhstan, and Nigeria. The fourth group, in the bottom-left quadrant, has neither the high-tech sectors nor the workforces, which applies to most developing countries.

For many countries, these technologies may seem distant prospects, but all will be affected by them sooner or later, so they need to anticipate the implications of the fourth industrial revolution on their economic and social systems.[84] Typically, most firms are at the stage of Industry 2.0.[85] This was corroborated by a firm-level survey in Argentina, Brazil, Ghana, Thailand, and Viet Nam.[86] For instance, in Ghana most firms were using analogue or rigid production, typically using computer-aided design only in product development. In Argentina, only 3 per cent of firms were using digital technologies and in Brazil only 4 per cent.[87] These countries have technological 'islands' that lack significant backward and forward linkages within their domestic economies.[88]

In Ghana, a recent UNCTAD survey encompassing 500 firms found very low adoption rates of frontier technologies – 3.6 per cent for industrial robots, 5.2 per cent for cobots, 5.6 per cent for 3D printing, 9.6 per cent for big data and 4.6 percent for virtual reality. The ICT sector had the highest levels, followed by tourism, agro-processing, pharmaceuticals and textiles (Box IV-5).[89] The three main barriers to adopting digital technology were identified as lack of finance, attachment to existing practices and traditional ways of doing things, and insufficient support from government.[90]

In a firm-level study in Bangladesh, local managerial staff were found to know very little about the potential for digital technologies, or the concepts of the circular economy.[91] Similarly, in Brazil companies in the plastics industry, particularly the smaller ones, had little understanding of the potential for digital technologies for more sustainable production.[92]

Box IV 5
A firm-level survey in developing countries

UNCTAD has partnered with researchers from the University of Johannesburg, the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research of Ghana, and the University of Nice Sophia-Antipolis on firm-level innovation surveys in Ghana, South Africa, and Tunisia concerning the deployment and use of new technologies. This project proposes a framework survey that could be applied in other developing countries

In Ghana, by mid-2022, the survey had been completed in 500 establishments. The survey found high levels of awareness of frontier technologies but very low levels of adoption. Only 4.1 per cent of the firms surveyed had adopted Industrial Robots and Virtual Reality, mainly in the agro-processing sector. Firms adopting cobots and 3D Printing constituted 5.2 per cent, and 5.6 per cent respectively, mainly in textiles and ICT sectors. Highest adoption levels were for social media at 84 per cent and mobile banking at 71 per cent. The main motivations for adopting these technologies were seen to be improvements in productivity working conditions and competitiveness.

Source: UNCTAD.

B. CREATING A TWIN TRANSITION

To seize windows of opportunity created by these technologies, latecomer countries will need to build digital competency along with the necessary infrastructure and institutions, while building innovation capacity and overcoming financial barriers.[93]

This is a task for governments, for the private sector and other stakeholders. The levels of industrialization, digital infrastructure, technological and productive capacities as well as involvement in GVCs are highly contextual. Therefore, the strategic responses will differ for emerging developing economies and less technologically advanced countries.

This section presents a list of critical policy areas that stakeholders in latecomer countries should consider, accounting for their technological level, existing preconditions, and different involvement in specific GVCs.

Aligning digital and green strategies

Several latecomer countries have national strategies for frontier technologies in the manufacturing sector. Examples are the 'Make in India' and 'Made in China 2025' programmes and the 'Industry 4.0 Agenda' in Brazil. In Africa, there are currently 83 strategic plans involving renewable energies, in Central and South America there are 65 plans, and in the Middle East 15.[94] Several developing countries have national strategies for enhancing digitalization, including Thailand, Viet Nam, South Africa, Chile, Argentina, Brazil and Mexico.[95]

Nevertheless, in the environmental and energy domain these strategies are often not coordinated with interventions or initiatives. In Bangladesh for example, footwear manufacturers have been found to have little motivation for adopting green technologies given the lack of environmental regulations and the general low level of environmental awareness.[96] Another study in Brazil finds that while the environmental laws are good, these are not linked with industrial policies.[97]

To take advantage of green windows of opportunity arising from the twin transitions in GVC manufacturing, policies need to be co-created across the energy-environmental, industrial and foreign investment spheres.

In the EU, Canada and the Nordic-Baltic countries, there is an increasing awareness of opportunities offered by digitalization for environmental protection and climate action, and of the need to reduce the environmental impacts of digitalization itself.[98]

Developing digital infrastructure

As these technologies progress, all countries will need stronger digital infrastructure, in particular high-speed and high-quality Internet connections.[99] There are, however, significant technological inequalities.

Concerning the fixed broadband connection, the observed average speed in developed economies (around 115 megabits per second) was almost eight times that of the least developed countries (LDCs) (around 15 megabits per second), reflecting infrastructure and technological.[100] But the technology divide is also visible within the same groups of countries and between rural and urban areas. An UNCTAD survey in 2021 found that 16 per cent of rural populations in LCDs had no access to any mobile network and 35 per cent could not connect using a mobile device.[101] In addition, the World Bank Enterprise Surveys[102] showed that more than 20 per cent of the interviewed companies in South Asia and around 14 per cent in Sub Saharan Africa identified electricity access as their biggest obstacle, which impacts their ability to use the Internet. Another constraint is the high cost of connectivity relative to income.[103] Moreover, the lack of reliable Internet access has been underlined in studies in Brazil[104] and India.[105]

Governments in developing countries should ensure high-quality Internet access. This will mean public and private investments in ICT infrastructure along with regulations to foster competition in the telecommunications sector. Governments should also address the connectivity gap between small and large firms and between urban and rural regions.

Some technologies may also need specific regulations. This would be the case for drones, which could help deliver lightweight, high-value goods, such as medical supplies, to remote areas. For instance, Rwanda is now allowing airspace to be accessed by pilotless aircraft.[106]

Building digital skills

UNCTAD has identified skills at four different levels – for adopting technologies, for basic use, for adapting technologies, and finally for creating new ones.[107] For developing countries it is particularly important to have the capacity to adapt and modify technologies since these are likely to be used in circumstances different from those in which they were originally developed.

Governments need to support businesses, including SMEs, to help them build digital skills in areas such as market research, product development, sourcing, production, sales, and after-sales services.[108] Special consideration should be given to women in informal and artisanal small and microenterprises, particularly for entrepreneurs.[109]

In Malaysia, for example, the Penang Skill Development Centre provides technical knowledge and organizes training programmes for advanced industrial operations.[110] Another relevant institution in Malaysia is CREST, an R&D consortium that researches Industry 4.0 topics and provides scholarships for advanced degrees. In Thailand, the Government, in collaboration with the Government of Japan, has established the Automotive Human Resource Development Program to upgrade the skills of local suppliers: domestic universities and research institutes are training engineers and technicians in AI, robotics, and mechatronics.

Countries also need to reduce brain drain, retain skilled professionals, and attract skilled expatriates. An interesting example is the NerUzh program in Armenia, which offers start-up funding designed to attract potential tech entrepreneurs from the diaspora.[111]

Building international partnerships

In the European Union, 26 member states, along with Norway and Iceland, have signed a declaration to accelerate the use of green digital technologies, deploy energy-efficient AI solutions and introduce digital passports to track products and improve circularity and sustainability.[112]

Developing countries in particular can benefit from participation in international projects and organizations.[113] An example is Prospecta Americas, a regional programme aimed at improving knowledge about technologies such as big data, AI, IoT, robotics, blockchain, and at evaluating their economic, social and environmental impact across OAS member states.[114] Another example is the UNIDO multi-stakeholder platform for sharing available tools and methods for digital transformation among SMEs.[115]

The UNDP is supporting projects aimed at building cross-sectoral ecosystems of partnerships across governments, companies, and NGOs. In Armenia, for example, the ImpactAim Venture Accelerator, in cooperation with the Enterprise Incubator Foundation, Innovative Solutions and Technologies Center Foundation, is supporting energy efficiency and exploring the application of AI and data sciences in the environmental field. The project is accelerating 33 start-ups in Armenia, two in Belarus and one in the Philippines[116]. Accelerators and incubators can facilitate learning and diffuse knowledge through best practices and demonstration projects.

Setting standards and regulations

Following international standards helps ensure interoperability and promotes productivity and innovation. Standardization offers obvious benefits in international trade networks and within global value chains – strengthening SDG pillars and their impact on the environment.[117] Regulations and standards are also important for securing data privacy.[118] In the case of 5G technology standard setting also involves political considerations.[119]

The International Communication Union (ITU) publishes international standards related to industry 4.0 and associated technologies such IoT. These standards are available free of charge for downloading and use in developing countries. ITU also organizes events that enable countries to obtain new knowledge and works with developing countries to bridge standardization gaps and assist them to become more involved in standardization activities.[120] The ITU has established focus groups that address the environmental efficiency industry of 4.0 technologies, as well as water and energy consumption, and provide guidance on how to operate these technologies in a more environmentally efficient manner.[121]

Providing financial support

Most developing countries have few resources for R&D programmes in digital and green technologies and the use of Industry 4.0. Smaller companies in particular find it difficult to make the necessary investments. In India for example, such companies have struggled to invest in the necessary technology in the automotive, metals and machinery, food, textile, and electrical equipment industries.[122] Similarly in Brazil many companies lack the necessary investment funds.[123, 124]

If companies are to combine both green and digital objectives, they will need convincing evidence about the return on investment. In Brazil for example most companies investing in digital technologies are doing so primarily to boost productivity.[125] For this purpose, the public sector, in partnership with international donors and development banks, needs to set up demonstration projects.[126]
A number of countries have established innovation and technology funds, sometimes in collaboration with international donors or multinational development banks

- *Malaysia* – The Bank Pembangunan has allocated RM3 billion in its Industry Digitalisation Transformation Fund (IDTF).[127]
- *Peru* – The ProInnovate Program funds and provides technical support for Industry 4.0 projects.
- *Türkiye* – Small and Medium Enterprises Development Organization of Turkey (KOSGEB) funds SME investment projects products medium-high and high-technology manufacturing.
- *Philippines* – The small enterprise technology program (SETUP) offer seed funds for acquiring technology along with training and other forms of support.[128]
- *South Africa* – The post-COVID recover plan[129] includes support for MSMEs for green innovation, and an artificial intelligence institute.[130]
- *Uganda* – Uganda Green Enterprise Finance Accelerator facilitates the flow of green finance by strengthening green SMEs and improving available financial mechanism.[131]

These activities are complemented with foreign direct investment (FDI). Governments can encourage FDI with public investments infrastructure and offering incentives for companies that adopt green and digital technologies.[132] An example is the Green Channel initiative in Latvia, which offers a fast track for FDI in fields such as ICT, bioeconomy, smart materials, smart energy, and mobility.[133]

1 OECD, 2020.

2 Data are available at https://www.wto.org/english/news_e/news22_e/stat_04feb22_e.htm.

3 "[T]he drive to increase supply-chain resilience will not lead to a "rush to reshore" but could become a "drag on development", with new investments in international networks no longer looking for locations offering low cost factors of production to the same degree" (UNCTAD, 2021) (177). Also see for example Gereffi et al., 2021; Miroudot, 2020.

4 De Marchi et al., 2019

5 The techno-economic paradigm driven by information and communication technologies (Perez, 2013).

6 Surana et al., 2020; Zhang and Gallagher, 2016; Amendolagine et al., 2021

7 De Marchi et al., 2019

8 De Marchi et al., 2019

9 Alves Dias et al., 2020

10 Gallagher et al., 2019

11 Beise and Rennings, 2005

12 Ponte, 2020

13 Lema et al., 2020

14 Pietrobelli and Rabellotti, 2011

15 UNDP - Chief Digital Office, 2022

16 Strange and Zucchella, 2017

17 Rodrik, 2018

18 ILO, 2020.

19 UNIDO, 2019

20 UNCTAD, 2018a

21 Akileswaran and Hutchinson, 2019

22 Banga, 2022

23 Akileswaran and Hutchinson, 2019

24 Delera et al., 2022

25 WTO, 2019

26 UNIDO, 2019

27 For more information about Cloudfactory and its presence in Nepal and Kenya see https://www.cloudfactory.com/hs-fs/hub/351374/file-1151354869-pdf/press-files/gscouncil-In_Their_Own_Words_An_Interview_with_CloudFactory.pdf.

28 Pincheira et al., 2022OEMs, owners, users, and inspectors

29 Sánchez and Hartlieb, 2020

30 Sánchez and Hartlieb, 2020; *Project Sindicate*, 2021

31 *Project Sindicate*, 2021

32 Sánchez and Hartlieb, 2020

33 De Marchi et al., 2019

34 Andreoni and Anzolin, 2019

35 Gale et al., 2017

36 Mangina et al. (2020) drawing on data from EU and EFTA.

37 UNCTAD, 2022e

38 Efficiency Vermont, 2020

39 Elmo Motion Control Ltd, 2020

40 Huang et al., 2016

41 UNCTAD, 2022e

42 Toniolo et al., 2020. AI is relevant to addressing several targets across the SDGs but it is also an obstacle in certain cases. In the energy field the data centres used to power AI have a very high energy demand (Vinuesa et al., 2020).

43 Nikolakis et al., 2018

44 Echochain (Echochain, 2022) measures the impact of product portfolios and measures and designs sustainable products. ElectricChain (Positive Blockchain, 2022) is a project that verifies and publishes data from solar energy generators. Suncontract (Sun contracting, 2022), as the name indicates, is a contracting model for commercial users that avoids the need of users buying the photovoltaic system.

45 Saberi et al., 2019

46 UNEP, 2019

47 Dauvergne, 2020

48 Ibid.

49 Golini et al., 2018; Jin et al., 2022; Wang et al., 2022

50 e.g., LEED; ISO 14001

51 Khattak et al., 2015

52 De Marchi and Di Maria, 2019

53 Poulsen et al., 2018

54 For a discussion on environmental sustainability and the maritime industry, see (UNCTAD, 2019a).

55 Virtual vessel arrival systems offer a low-cost strategy to reduce these emissions by informing vessel operators of expected delays and aligning arrival times with berth availability.

56 IMO, 2022

57 https://unctad.org/project/sustainable-smart-ports-african-countries-including-small-island-developing-states-recover

58 Ponte, 2020

59 Achabou et al., 2017.

60 Khan et al., 2020

61 UNFSS, 2013

62 UNFSS, 2020

63 Those VSS organisations include: 4C Services (4C), Better Cotton Initiative (BCI), Bonsucro, Cotton made in Africa (CmiA), Fairtrade International (Fairtrade), Forest Stewardship Council (FSC), GLOBALG.A.P., IFOAM, Programme for the Endorsement of Forest Certification (PEFC), ProTerra Foundation (ProTerra), Rainforest Alliance (Rainforest), Roundtable on Sustainable Palm Oil (RSPO), Round Table on Responsible Soy (RTRS) and UTZ (a programme and certification scheme for sustainable farming) (Elamin and Fernandez de Cordoba, 2020).

64 Global Survey on Voluntary Sustainability Standards, 2022

65 UNFSS, 2020

66 Opperskalski et al., 2020

67 https://standardsmap.org/en/factsheet/30/overview?origin=&products=&name=Global%20Organic%20Textile%20Standard%20-%20GOTS

68 https://www.fairtrade.net/

69 https://www.climate-standards.org/ccb-standards/

70 Global Survey on Voluntary Sustainability Standards, 2022

71 https://www.msc.org/

72 https://www.responsiblemines.org/en/

73 https://standardsmap.org/en/factsheet/468/overview?origin=&products=&name=Fairtrade%20International%20-%20Gold%20Standard

74 https://verra.org/project/vcs-program/

75 https://responsiblesoy.org/about-rtrs?lang=en

76 https://wildlifefriendly.org/tag/certified-wildlife-friendly/

77 UNCTAD, 2022

78 Source: UNIDO, 2019. The countries are USA, Japan, Germany, China, Taiwan, France, Switzerland, UK, Korea, and The Netherlands.

79 According to UNIDO (2019) the top 10 exporting countries are Germany, Japan, China, Italy, Taiwan, Austria, USA, Korea, Switzerland, and France. The top importing countries are China, USA, Germany, Mexico, Russia, Italy, India, UK, Türkiye, and France.

80 UNIDO, 2019

81 Followers in production are identified based on their patenting or export activities while followers in use based on import of digital related technologies. Three more groups of countries are identified: latecomers in production including 16 economies, latecomers in use with 13 countries and laggards (88 countries) showing no or very low engagement with I4R technologies. For details about the classifications see UNIDO, 2019.

82 UNIDO, 2019

83 Auktor, 2022

84 UNCTAD, 2022.

85 Cirera et al., 2022; Lee, 2019

86 UNIDO, 2019

87 Andreoni and Anzolin, 2019

88 Matthess and Kunkel, 2020

89 Essegbey et al., 2022

90 Essegbey et al., 2022; UNCTAD, 2022f

91 Dwivedi et al., 2022

92 Nara et al., 2021

93 UNCTAD, 2022e.

94 Information is available at https://www.iea.org/policies?type=Strategic%20plans&region=Africa%2CCentral%20%26%20South%20America&status=In%20force&source=IEA%2FIRENA%20Renewables%20Policies%20Database.

95 UNIDO, 2019 and UNCTAD, 2022.

96 Dwivedi et al., 2022

97 Cezarino et al., 2019

98 For more information see (https://www.consilium.europa.eu/en/press/press-releases/2020/12/17/digitalisation-for-the-benefit-of-the-environment-council-approves-conclusions/) and Nordic Council of Ministers (2021).

99 UNCTAD, 2021c

100 UNCTAD, 2021a

101 UNCTAD, 2021c

102 Data are available at enterprisesurveys.org.

103 UNCTAD, 2021c

104 Cezarino et al., 2019

105 Luthra and Mangla, 2018

106 World Economic Forum, 2019

107 UNCTAD, 2019b

108 UNCTAD, 2022

109 UNCTAD, 2014a, 2019b

110 Lee et al., 2020

111 More information about the NerUzh program is available at http://diaspora.gov.am/en/programs/31/neruzh

112 More information is available at http://diaspora.gov.am/en/programs/31/neruzh

113 UNCTAD, 2022

114 More information is available at http://diaspora.gov.am/en/programs/31/neruzh

115 UNCTAD, 2022

116 More information is available at impact.aim.com.

117 UNIDO, 2021

118 Luthra and Mangla, 2018

119 For details see the article *China, US and Europe vie to set 5G standards* on https://www.ft.com/content/0566d63d-5ec2-42b6-acf8-2c84606ef5cf (February 6th, 2022)

120 UNCTAD, 2022

121 More information is available at https://www.itu.int/en/ITU-T/focusgroups/ai4ee/Pages/default.aspx.

122 Luthra and Mangla, 2018

123 Cezarino et al., 2019the authors aim to explore the relationship between the concepts of Industry 4.0 and circular economy

124 Nara et al., 2021

125 Nara et al., 2021

126 UNCTAD, 2022

127 UNCTAD, 2022e

128 Contribution from UNIDO

129 https://www.gov.za/sites/default/files/gcis_document/202010/south-african-economic-reconstruction-and-recovery-plan.pdf

130 Contribution from UNEP

131 https://ugefa.eu/

132 UNCTAD, 2022d

133 More information is available at investinlatvia.org.