Innovation for development

The key to a **transformative recovery** in Latin America and the Caribbean

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Third meeting of the
Conference on Science, Innovation and Information and Communications Technologies of the
Economic Commission for Latin America and the Caribbean

Virtual meeting, 13–15 December 2021

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Executive Secretary

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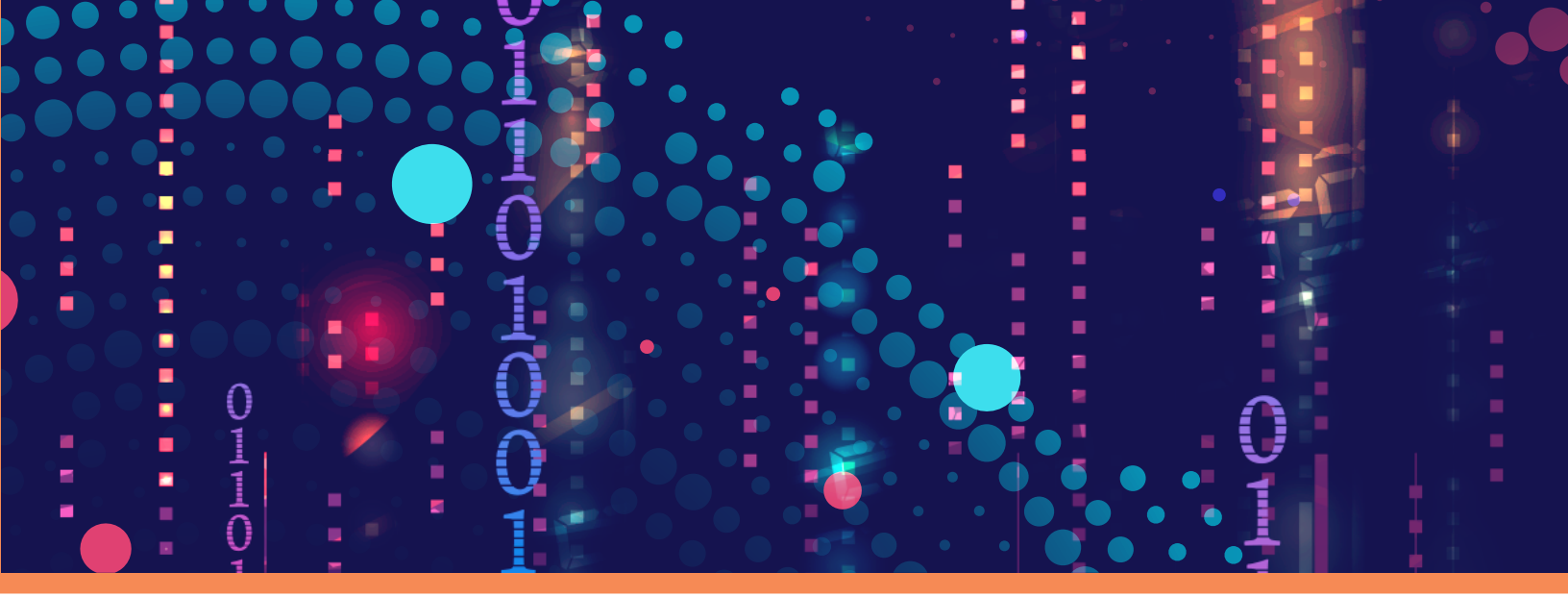


Foreword

In the years since the second session of the Conference on Science, Innovation and Information and Communications Technologies of the Economic Commission for Latin America and the Caribbean was held in San José in 2016, climate change and global warming, migration, digital disruption, access to health care and medication, and gender equality, among many others, have acquired greater importance and moved to the forefront of the global agenda. Latin America and the Caribbean is no stranger to these issues and has developed strategies and agendas to address many of them at both the national and regional levels, promoting spaces for dialogue and intra- and interregional cooperation.

Yet, in the first months of 2020, the appearance of the most complex situation in recent decades dramatically changed the reality of the world and the region. Almost two years of pandemic have been enough to reveal some of the structural problems facing Latin America and the Caribbean as it transitions towards a new stage of development. At the regional level, it is essential to revitalize the areas of action and cooperation to facilitate a transformative recovery that can reduce social inequalities and productive heterogeneity, improve competitiveness and mitigate the environmental vulnerability many citizens face.

The fall in income levels, the closure of a significant number of businesses, the increase in levels of poverty and social vulnerability, greater exposure to the effects of climate change and unequal access to certain essential goods and services have brought to the fore the urgent need to strengthen the role of the State and public policies in all areas of development: economic, productive, social, environmental and institutional. The coronavirus disease (COVID-19) pandemic has had an unprecedented economic and social impact in Latin America and the Caribbean. In 2020, GDP fell by 6.8%, the value of exports decreased by 13% and 2.7 million businesses closed, which had a considerable impact on employment. The most visible reflection of these dynamics has been the increase in levels of poverty and inequality. It is estimated that the number of people living in poverty grew by more than 22 million, rising to 209 million people (33.7% of the total population of Latin America and the Caribbean), while the Gini index recorded an increase of 2.9%, with women and children the most affected.

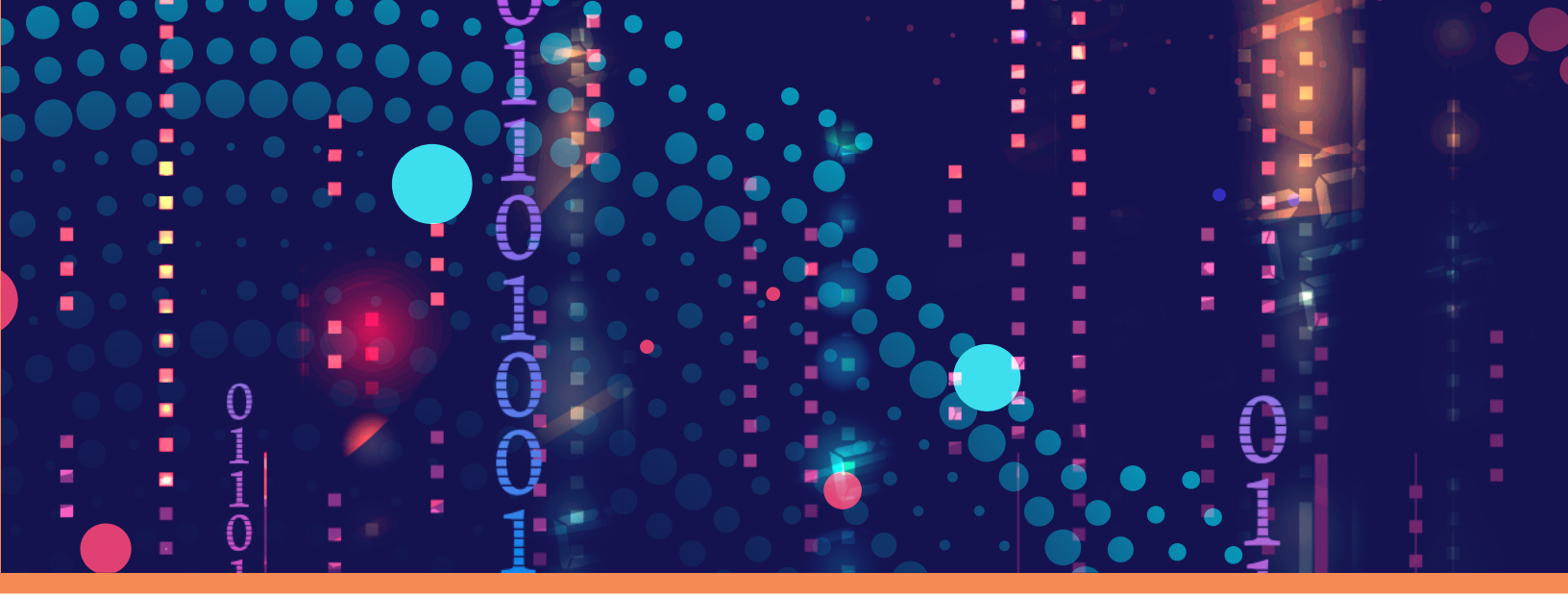
The COVID-19 crisis has also taught us a number of lessons, one of which is the importance of science, technology and innovation to development, not only in responding to short-term needs caused by the pandemic, but also in addressing structural demands associated with increasing productivity and added value; creating new and better jobs; improving access to essential goods and services, such as health care and education, and making changes to production and consumption patterns to develop more sustainable processes, among many other transformations that, ultimately, facilitate progress towards more inclusive and sustainable societies.

The present document, prepared for the third session of the Conference on Science, Innovation and Information and Communications Technologies of the Economic Commission for Latin America and the Caribbean, is intended to contribute to the debate, and to actions related to development and the further deployment of science, technologies and innovation in the region to achieve health autonomy, digital inclusion and the development of solutions for more sustainable consumption and production. All of these elements may contribute to a transformative recovery that forges a new path towards a more inclusive and sustainable development for the region, in compliance with the 2030 Agenda for Sustainable Development and the Sustainable Development Goals.

Without claiming to be an exhaustive analysis of the reality of science, innovation and new technologies in the region, this document uses a number of traditional indicators to take into account the current state of science, technology and innovation in Latin America and the Caribbean, as well as recent developments in institutional frameworks, policies and related support instruments (chapter I). The COVID-19 pandemic has revealed the central role of health systems and of scientific and technological capacities in responding to the demands of the population and becoming true drivers of technological and productive change for developing countries (chapter II). The importance of digital technologies is undeniable; the digital revolution —which combines the adoption and integration of advanced digital technologies, such as fifth generation (5G) mobile networks, the Internet of things, cloud computing, artificial intelligence, big data analysis and robotics— is rapidly transforming the economy and society owing to its potential to, among other benefits, increase personal well-being, transform business productivity and improve national efficiency and effectiveness (chapter III). In addition, the link between sustainable consumption and production and technological and eco-innovation

capabilities is essential to making progress in implementing the 2030 Agenda and achieving the Sustainable Development Goals, especially in countries transitioning to development, such as those in Latin America and the Caribbean (chapter IV). As a whole, the document considers the main challenges facing the region in science, innovation and new technologies, while highlighting the roles of various stakeholders and how they can work together to strengthen spaces for cooperation.

Alicia Bárcena
Executive Secretary
Economic Commission for Latin America and the Caribbean



Main messages

Science, innovation and new technologies are undeniably crucial for the development of the economy and society: they have become fundamental tools for transformation of productive structures, rational use of natural resources, health care, food, education and other social needs.

However, Latin America and the Caribbean is lagging considerably in terms of the resources allocated to science, technology and innovation. Although there has been significant progress with the public institutional framework to support these areas in recent years, either by establishing thematic ministries or by strengthening specialized institutions, science, technology and innovation remain largely absent in productive and social development policies or in countries' budgets. Indeed, within national priorities, basic science —essentially that of universities and research centres— continues to predominate over applied science and experimental development, which are led by the private sector. Moreover, the range of policy instruments to support science, technology and innovation appears incomplete and insufficient to significantly boost these areas at the regional level.

At present, Latin American and Caribbean efforts in science, technology and innovation do not appear sufficiently aligned with capacity-building and responses to crucial challenges at the national level. In fact, the widespread use of demand-driven competitive funds is based on the notion that researchers are best suited to identify areas of work in science and technology and that businesses are best positioned to do so in the case of innovation. This has had several consequences: (i) projects with meagre funding, low socioeconomic impact and limited market reach; (ii) a large number of projects without a strategic focus, which hampers building of innovation-intensive capacities; (iii) prioritization of short-term projects, dependent on political cycles, which do not address strategic thematic areas; and (iv) weak local capacities to address priority challenges.

In an increasingly complex world, science, technology and innovation cannot be viewed in isolation from governments' and societies' other areas of concern. Therefore, a sizeable portion of the resources assigned to these areas should be focused on areas of knowledge that are related to countries' challenges. In view of this situation, there has been ever greater conviction of the crucial role of public policy in supporting science, technology and innovation. Many countries, and especially advanced economies, have thus begun to revive industrial policy with a focus on complex, comprehensive and capable national innovation systems, which have made it possible to mobilize productive, technical and knowledge capacities to address key development challenges. In other words, priority is given to support for research —mainly applied research— that enables resolution of specific challenges, without neglecting the development of more generic scientific capacities to expand the frontiers of knowledge. This approach calls for coordination between various stakeholders (government, academia, the private sector and civil society) and new institutional arrangements must be established for coordination and for capacity-building in formulation and management of policy.

The challenges posed by the coronavirus disease (COVID-19) pandemic have prompted several countries to adopt more ambitious, integrated and long-term strategies. The current situation has made it clear that these processes need to be constantly reviewed, not only in terms of the thematic areas addressed by researchers and innovators, but also in terms of the effectiveness of available instruments and whether new ones must be established.

In Latin America and the Caribbean, for example, the pandemic has led to a re-evaluation of strategic alternatives regarding the supply of medicines and medical devices. Strengthening of national and regional health industry capacities has therefore been identified as a priority, as reflected by the unanimous adoption of the *Plan for self-sufficiency in health matters in Latin America and the Caribbean: Lines of action and proposals*[1] by the countries of the Community of Latin American and Caribbean States (CELAC). This requires enormous efforts, because of the characteristics of the sector, including: (i) significant gaps between local capacities and the technological frontier in industries where science, technology and innovation play a central role; (ii) a need for consistent long-term efforts to enable accumulation of scientific, technological and productive knowledge; (iii) a need to align multiple stakeholders and institutions, and a variety of goals; and (iv) significant economies of scale in production.

[1] See Economic Commission for Latin America and the Caribbean (ECLAC), *Plan for self-sufficiency in health matters in Latin America and the Caribbean: Lines of action and proposals* (LC/TS.2021/115), Santiago, 2021.

Despite the complexity of the health industry, the right conditions can be created to strengthen the sector at the national and regional levels. Key measures include: (i) increasing government contributions to research and development activities; (ii) extending the scale and deadlines of projects to be implemented; (iii) strengthening public, university and private centres of excellence; (iv) fostering connections between stakeholders in the health industry innovation system; (v) improving product and process patent, registration and approval processes; and (vi) monitoring procurement in the health industry innovation process.

In this context, regional cooperation is key. This requires some of the following measures: (i) developing innovation programmes that aim to resolve shared challenges through regional transnational consortiums; (ii) fostering integration in the field of training and exchanges of students and researchers; (iii) extending and formalizing mutual recognition of drug registration; (iv) complementing installed capacity in the countries with a regional clinical trials platform designed to consolidate common and recognized regulatory standards; (v) regulating procurement strategies by creating a base of suppliers that guarantee compliance with quality and safety standards and timely delivery at reasonable prices; and (vi) strengthening regional mechanisms for joint procurement of medicines and medical devices in health emergencies.

The COVID-19 pandemic has also accelerated and mainstreamed the use of digital technologies. Therefore, the need for policies to boost and organize digital activities has become more urgent and critical. Whether a new path of development can be followed, and whether progress can be made towards a transformative recovery, will depend largely on events in the digital sphere and how changes are incorporated into the economy and society.

Governance structures for digital development must address the update of legal frameworks in areas such as telecommunications, competition, employment, taxation and trade; moreover, new regulations and institutions need to be established in areas such as cybersecurity, personal data protection, data flows, ethics and artificial intelligence. It is also vital to prioritize public and private actions that strengthen and drive digital ecosystems, so that the complexities, benefits and challenges of the new, fast-growing technological alternatives can be understood and leveraged: fifth generation mobile networks (5G), the Internet of Things (IoT), cloud computing, artificial intelligence (AI), big data analytics and robotics.

The cross-border nature of the digital economy, and of the related actors and flows, calls for alignment with international progress and guidelines in several areas, while considering national situations and outlooks. Therefore, there is an increasingly pressing need for regional coordination of various legal and regulatory aspects, relating to trade, taxation, data flows, data protection and cybersecurity.

Digital governance should aim to build welfare states, driven by a competitive and sustainable production model based on new technologies. To achieve this, further progress is required on the creation of an inclusive digital society, digital transformation of the productive sector, strengthening of digital trust and security (cybersecurity), consolidation of fair and competitive digital markets, and establishment of regional cooperation mechanisms in the digital sphere. In relation to regional cooperation, an institutional framework must be built that facilitates discussion of policies, rules and standards; promotes links and convergence among subregional blocs and drives a regional digital market that enables a regional strategy to be formulated to increase trade, expand the digital economy and strengthen competitiveness through regulatory consistency, infrastructure integration, development of digital platforms, ease of cross-border data flows and trade facilitation measures. One noteworthy initiative in this respect is the Digital Agenda for Latin America and the Caribbean (eLAC), the goal of which is development of the digital ecosystem through a process of integration and regional cooperation, by strengthening digital policies that promote knowledge, inclusion and equity, innovation and environmental sustainability.

The 2030 Agenda for Sustainable Development and the Sustainable Development Goals highlight the urgent need to move towards new models of growth and development, with more sustainable and inclusive patterns of consumption and production. In fact, because of a growing awareness of climate change, companies are adopting environmental impact reduction strategies, especially in response to consumer demand for products and services that are environmentally responsible in different respects. Local communities are also lobbying

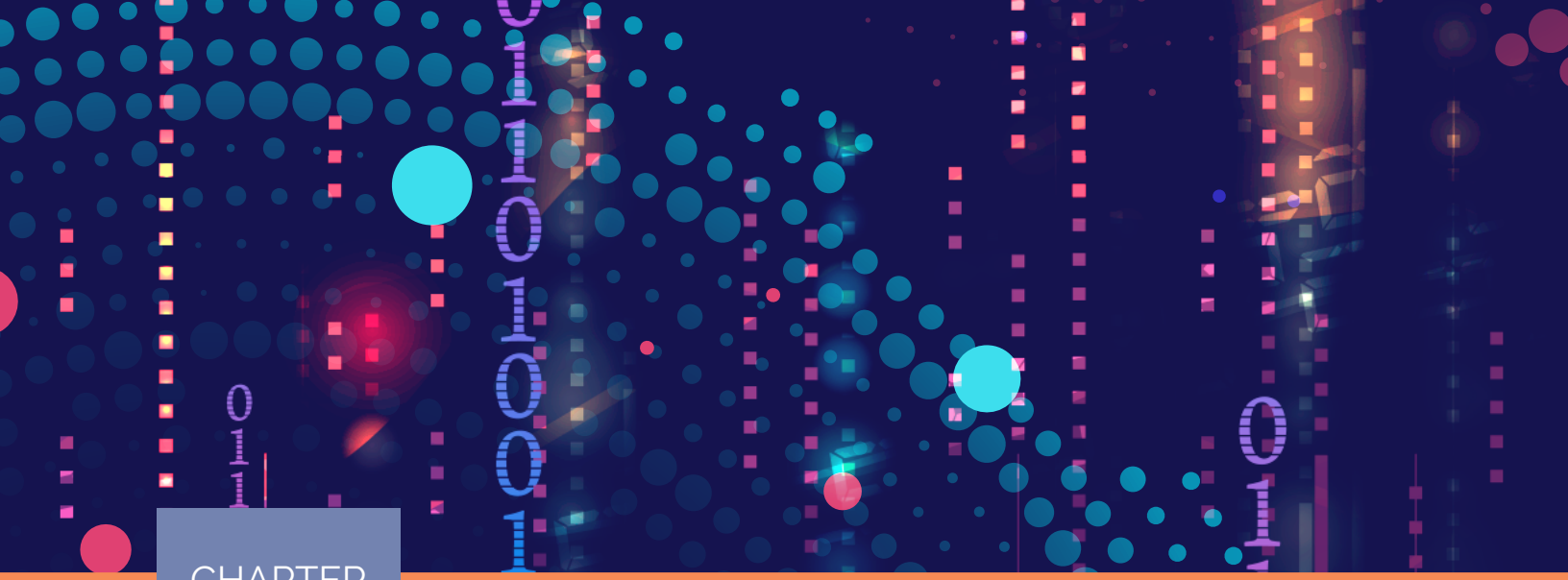
for respect for the natural ecosystems in which some companies operate. These trends, coupled with stricter environmental regulations and standards, are driving a variety of business and industry strategies.

Industry efforts and strategies to achieve sustainable production have shifted from a focus on end-of-process or end-of-life-cycle solutions for products to strategies that seek to prevent undesirable impacts by modifying products or production processes, as well as the inputs required for production.

Meeting sustainable production goals entails an integrated approach to policy formulation. This has been made clear by government initiatives in the areas of science, technology and innovation, as operational instruments have evolved from technological and sectoral funds, venture capital stimulus packages and cooperation among universities and companies to sustainable public procurement and various types of collaborative networks. The environmental dimension also adds complexity to these initiatives. Undoubtedly, to meet these demands and move towards a greener growth model, an integrated and cross-cutting framework for action must be pursued, accompanied by collaboration and dialogue among government, the private sector and civil society.

In Latin America and the Caribbean, initiatives have been launched to foster sustainable production and consumption; measures have also been implemented to establish environmentally sound policies on technological development and dissemination. Many of these initiatives to support technology dissemination and capacity-building are being carried out within national centres and programmes for clean production.

Lastly, in a world where economies of scale and scope are increasingly important in determining capacity to close technological gaps, it is vital to promote bilateral and multilateral cooperation actions to build, develop and consolidate scientific and technological capabilities, productive innovation processes, and institutional interlinkages. Therefore, implementation of regional projects is key to identifying potential areas of interest for cooperation in science, technology and innovation, which can, in turn, generate significant synergies with other existing regional cooperation spaces in Latin America and the Caribbean, or incorporated into such projects to strengthen scientific and technological development. Strengthening links and work between the countries of a region with more than 650 million inhabitants has the potential not only to open up business opportunities, with a considerable impact on creation of high-quality jobs, but also to create a seedbed of new knowledge and foster new technologies and science that meet the needs and demands of a society that is in transition to development.



CHAPTER

I

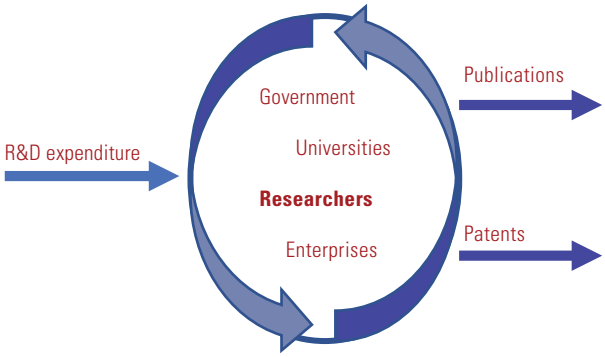
A brief overview of science, technology and innovation in Latin America and the Caribbean

This chapter provides a brief summary of the current state of science, technology and innovation in Latin America and the Caribbean. To that end, it includes a review of the traditional indicators associated with innovation systems, and an analysis of recent developments relating to institutionality, policies and related support instruments, concluding by analysing the conditions that have inspired these policies and considering how to make progress towards new regional paradigms.

A. The regional situation through the lens of basic indicators

While science, technology and innovation constitute a complex phenomenon involving interaction between numerous actors motivated by different interests and with different areas of implementation, there is no single indicator that makes it possible to determine the relevant capacities of countries, enterprises, universities and research centres. As a result, a set of indicators relating to inputs and outcomes is usually taken into account to enable a rough estimate to be made of capacities in science, technology and innovation. The most used input indicators are public and private expenditure on research and development (R&D) and the workers involved, namely researchers, technicians and other support staff. Meanwhile, the most used indicators for products or outcomes are scientific publications and patents derived from research activities, although patents are also considered inputs for the development of science, technology and innovation (see diagram I.1).[1]

Diagram I.1
Science and technology indicators



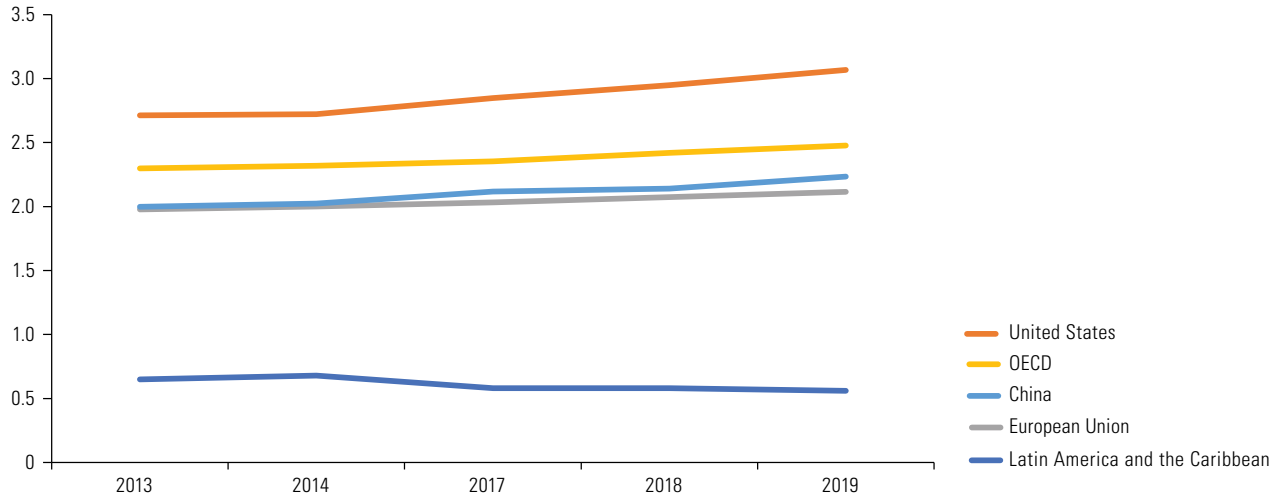
Source: Economic Commission for Latin America and the Caribbean (ECLAC).

1. Low R&D expenditure

There is a clear lack of R&D expenditure in Latin America and the Caribbean compared to more developed countries, and even in comparison to some emerging countries, such as China. The region has not only been unable to close this gap, but has also seen the gap widen in recent years. The United States of America, the European Union, the member States of the Organisation for Economic Co-operation and Development (OECD) and China have R&D expenditure relative to their gross domestic product (GDP) of above 2%. This figure reaches 3% in the case of the United States and exceeds 4% in the Republic of Korea. Moreover, R&D expenditure relative to GDP in these countries increased by around 0.2% between 2013 and 2019. Latin America and the Caribbean, in contrast, despite having R&D expenditure four times smaller relative to GDP, actually cut this spending by 0.65% of GDP in 2013 to 0.56% in 2019 (see figure I.1).

[1] Because of both the scope of this chapter and the availability of information, the indicators used are limited to research and development. While research and development processes differ from those relating to innovation, it is accepted that there is a positive correlation between them, as R&D indicators are considered an indirect reflection of innovation indicators at an aggregated level.

Figure I.1
Latin America and the Caribbean and selected countries and blocs: R&D expenditure in relation to GDP, 2013–2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org for Latin America and the Caribbean and Organisation for Economic Co-operation and Development (OECD), OECD.Stat [online database] http://stats.oecd.org/, for the United States, the European Union, OECD and China.

The situation varies at the regional level. A look at the evolution of R&D expenditure in absolute terms, between 2011 and 2019, reveals three groups of countries:

(i) those that were constantly increasing R&D expenditure to more than double it, such as Cuba, El Salvador and Peru;

(ii) those with an unclear trajectory and that recorded an increase of less than 20%, such as Chile, Colombia and Costa Rica, and

(iii) those with a tendency to reduce R&D expenditure, including Argentina, Brazil and Mexico.

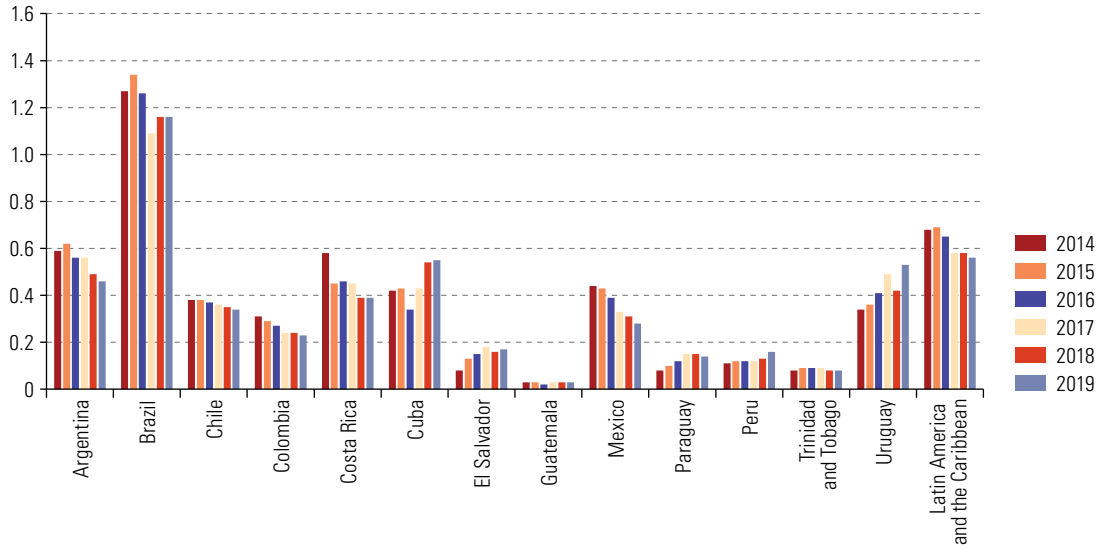
The reduction in expenditure of the last group of countries explains the total reduction in expenditure in Latin America and the Caribbean as a whole, as they account for 83% of the region's expenditure. Brazil alone accounts for 62%. In relative terms, with R&D expenditure as a proportion of GDP, the regional leader is also Brazil, which allocates 1.16% of its GDP to such activities. Among the countries for which we have information, Cuba and Uruguay are the next highest, with more than 0.5%, followed by Argentina with 0.46% (see figure I.2).

2. There has been little structural change in the funding and implementation of expenditure

Between 2003 and 2019, Latin America and the Caribbean maintained the same financing and expenditure implementation structure that had characterized the region in recent decades. Most funding for R&D expenditure in Latin American and Caribbean countries is provided by the State and the expenditure is mainly managed by academia, in contrast to more developed countries, where it is enterprises that primarily finance and implement expenditure.

In the case of China, the participation of enterprises in R&D financing accounts for almost 80% of the total, while in the United States, the European Union and OECD countries this indicator exceeds 60%. In Latin American and Caribbean countries, in contrast, the participation of enterprises in R&D financing stands at around 35%, while the State provides approximately 60%.

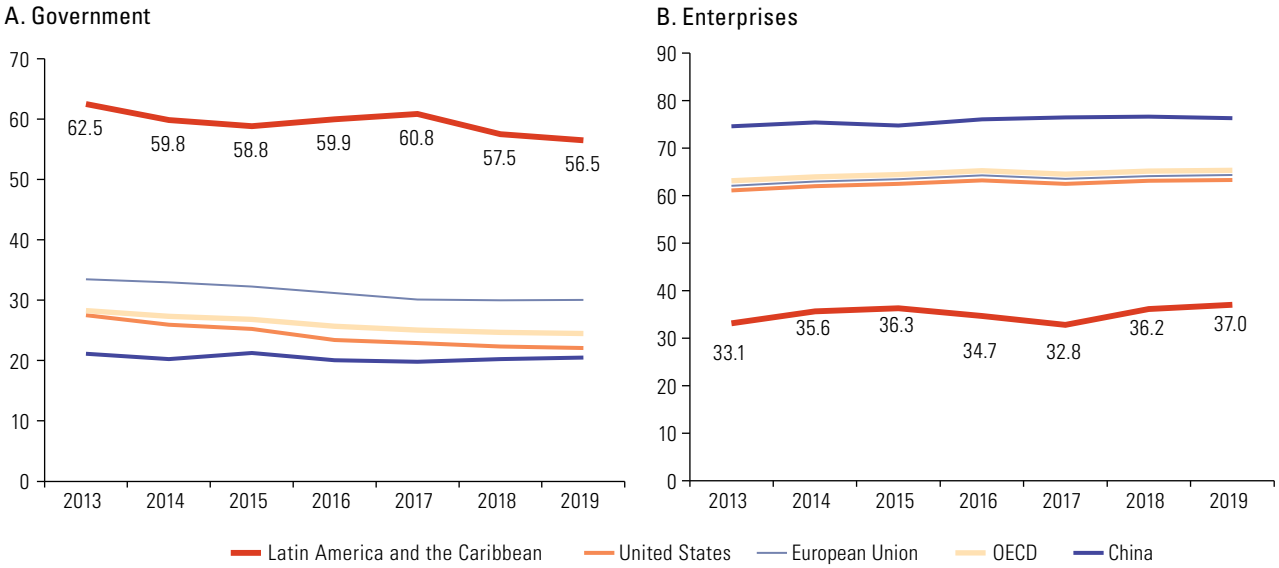
Figure I.2
Latin America and the Caribbean (13 countries): R&D expenditure as a proportion of GDP, 2014–2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.
Note: The data for Brazil, Costa Rica and Trinidad and Tobago are from 2018. The data for Latin America and the Caribbean are estimates.

The fall in R&D expenditure in countries in the region (both in absolute terms and in relation to GDP) is linked to the reduction of relevant government support, which in percentage terms decreased from 62.5% in 2013 to 56.5% in 2019 (see figure I.3). The implementation of R&D expenditure in the region shows a low level of participation on the part of the business sector. Enterprises implement around 30% of R&D expenditure in the region. Meanwhile, in economies with higher levels of development, enterprises implement between 65% and 75% of total expenditure. In Latin American and Caribbean countries, universities play a leading role in carrying out R&D activities, which are focused primarily on basic research (see figure I.4).

Figure I.3
Latin America and the Caribbean and selected countries and blocs: R&D expenditure by financing sector, 2013–2019
(Percentages)



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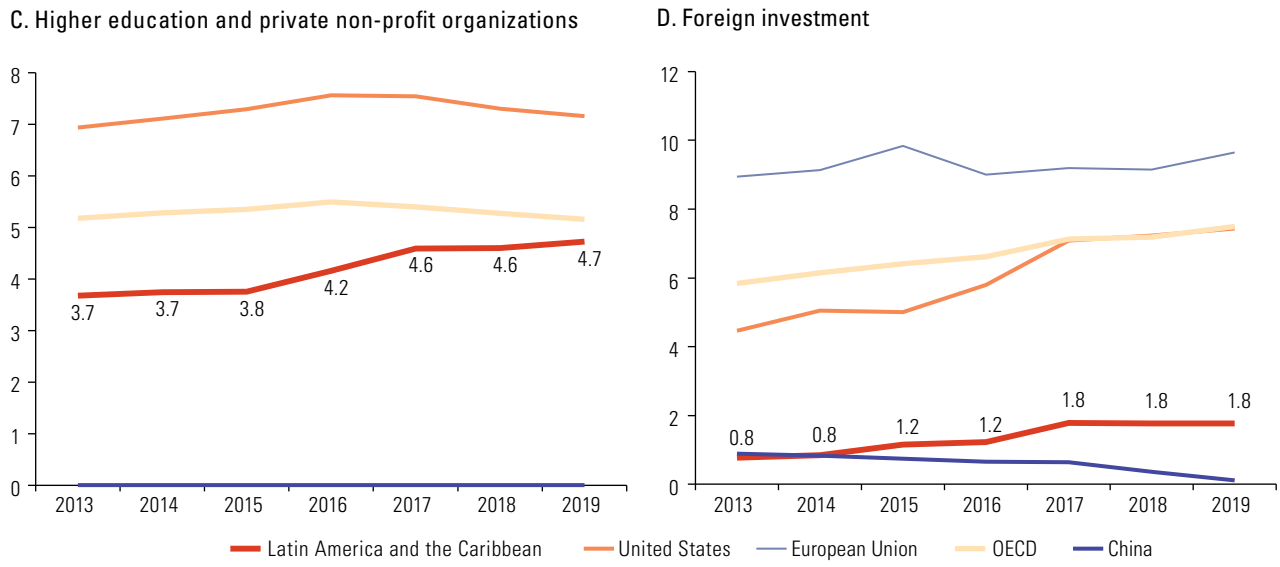


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org for Latin America and the Caribbean and Organisation for Economic Co-operation and Development (OECD), OECD.Stat [online database] http://stats.oecd.org/, for the United States, the European Union, OECD and China.

Figure I.4

Latin America and the Caribbean and selected countries and blocs: R&D expenditure by implementing sector, 2013–2019
(Percentages)

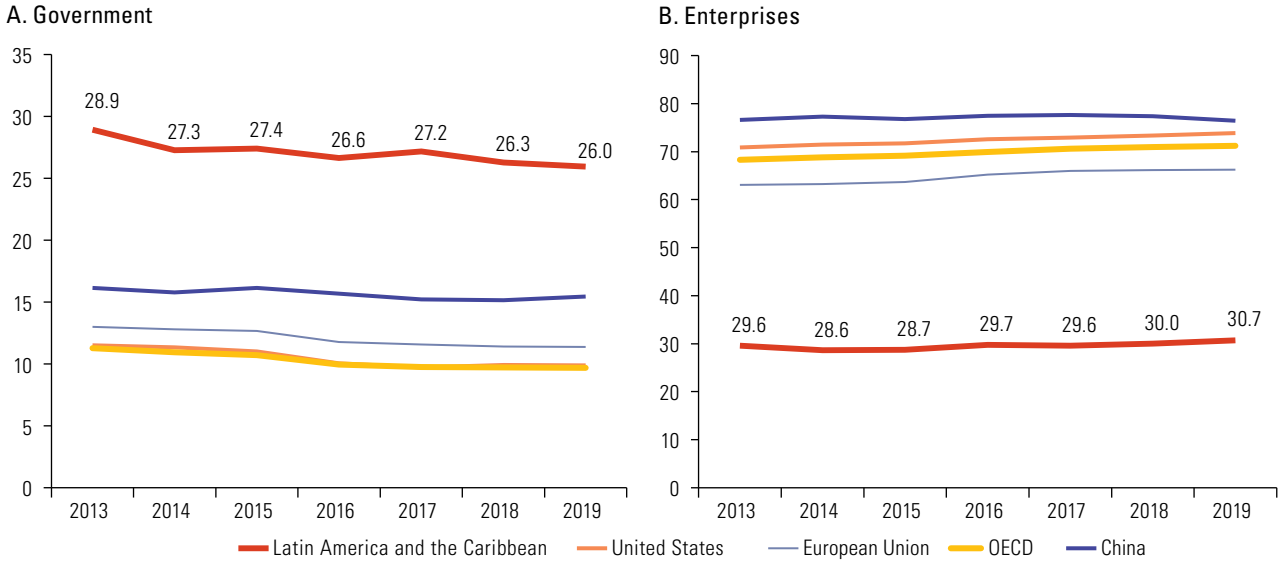
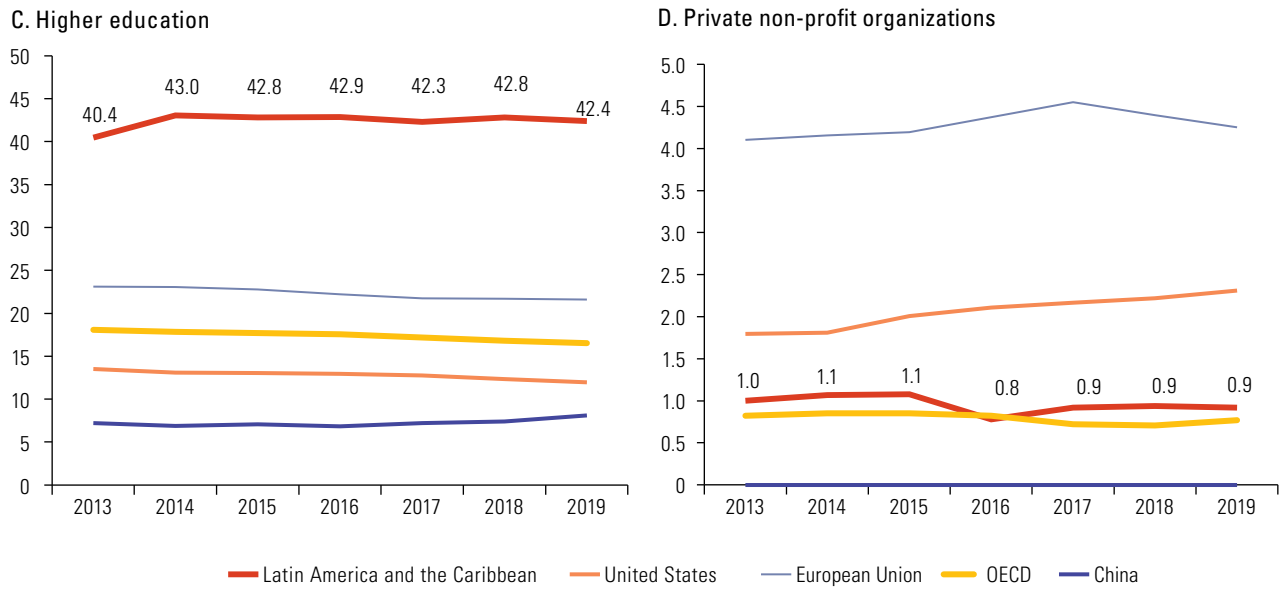


Figure I.4 (concluded)

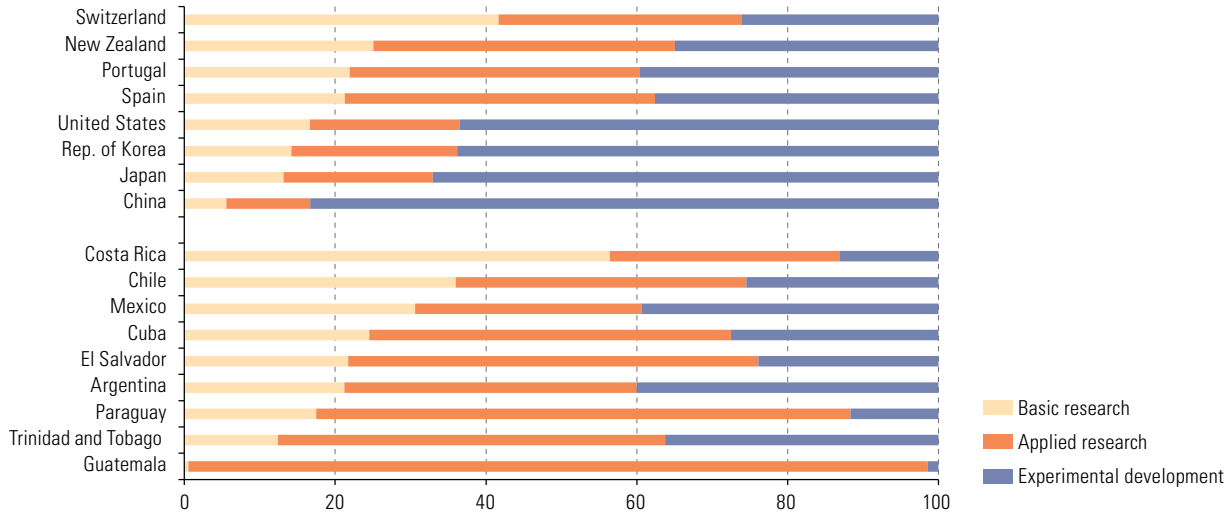


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org for Latin America and the Caribbean and Organisation for Economic Co-operation and Development (OECD), OECD.Stat [online database] http://stats.oecd.org/, for the United States, the European Union, OECD and China.

3. Basic research dominates at the regional level

Latin American and Caribbean countries primarily allocate R&D expenditure to basic research, while experimental research dominates in more developed countries (see figure I.5).

Figure I.5
Selected countries: R&D expenditure by type of research, around 2018
(Percentages)



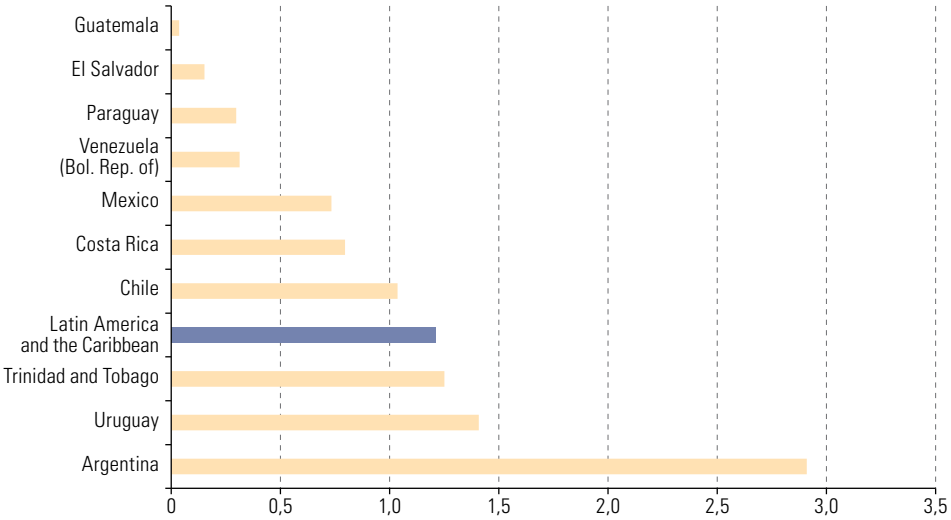
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org and UNESCO Institute for Statistics (UIS), UIS.Stat [online database] http://data.uis.unesco.org/.

4. Increasing human capital dedicated to science, technology and innovation

The number of researchers in the region, measured on the basis of the full-day equivalent working hours, stands at almost 386,000, reflecting a growth of more than 19% in the period from 2015 to 2019. In a scenario where R&D expenditure has not experienced an equivalent increase, no clear explanation can be obtained from the information available. In 2019, according to the Ibero-American Network on Science and Technology Indicators (RICYT), 63.2% of these researchers were employed in the academic sector, 11.1% in the public sector and 25.1% in enterprises, both public and private. These percentages are consistent with the available information on the distribution of R&D expenditure in the region.

Latin America and the Caribbean has an average of 1.21 researchers per 1,000 people in the economically active population. Argentina leads the way with this indicator, with almost 3 researchers per 1,000 people in the economically active population (see figure I.6).

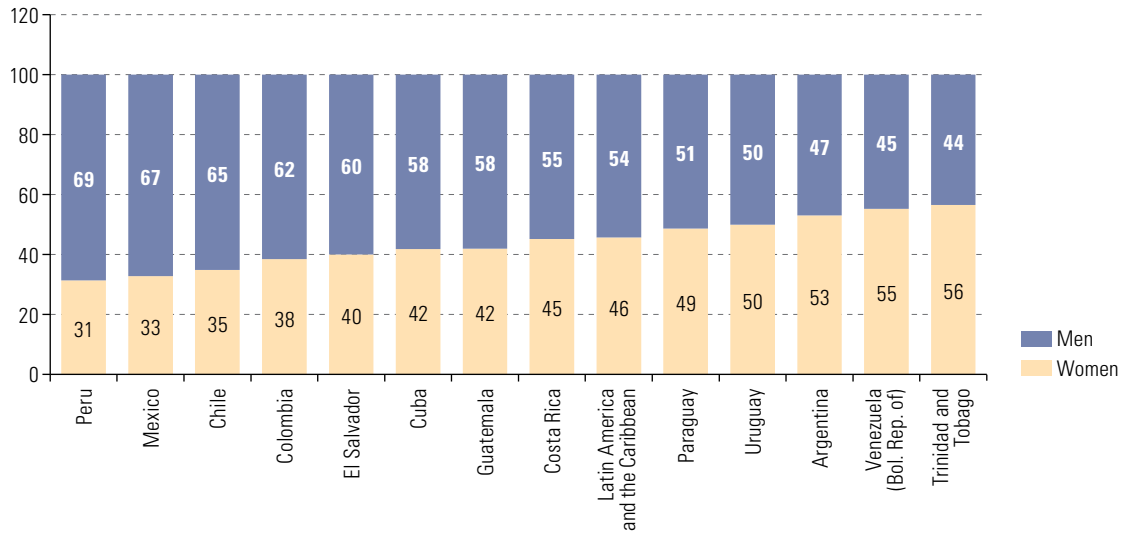
Figure I.6
Latin America and the Caribbean: proportion of researchers in the economically active population,[a] 2019
(Per 1,000 people)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.
Note: The data for Trinidad and Tobago and Costa Rica are from 2018.
[a] Full-day equivalent.

Of the total number of researchers in the region, around 46% are women. This figure is higher than the global average of 28% and is only surpassed by the rate in Western European countries (48.5%) (UNESCO, 2018). Notable in this regard are Argentina, Venezuela (Bolivarian Republic of) and Trinidad and Tobago, where over half of researchers and assistants at the national level are women. At the other extreme, Chile, Mexico and Peru have a lower proportion of female researchers and assistants (see figure I.7). According to RICYT, the percentage of female researchers has remained largely unchanged for more than seven years. The rate of participation is even lower for project managers or directors of research centres, indicating the progress that is still needed in this field.

Figure I.7
Latin America and the Caribbean (13 countries): researchers by gender, 2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.
Note: The data for Costa Rica and El Salvador are from 2018. The data for Latin America and the Caribbean are estimates.

Among the Latin American and Caribbean countries for which we have information, the greatest proportion of female researchers by scientific discipline is found, without exception, in medical sciences. In contrast, the lowest proportions of female researchers are in engineering and technology, and agricultural sciences (RICYT, 2019).

In terms of the sectors employing female researchers, in the cases for which we have information, it is clear that the recruitment of female researchers by companies is proportionally lower than in other sectors. For example, in Argentina, where 53% of researchers are female on average, women account for only 32% of researchers in the business sector.

5. Performance criteria determine scientific output

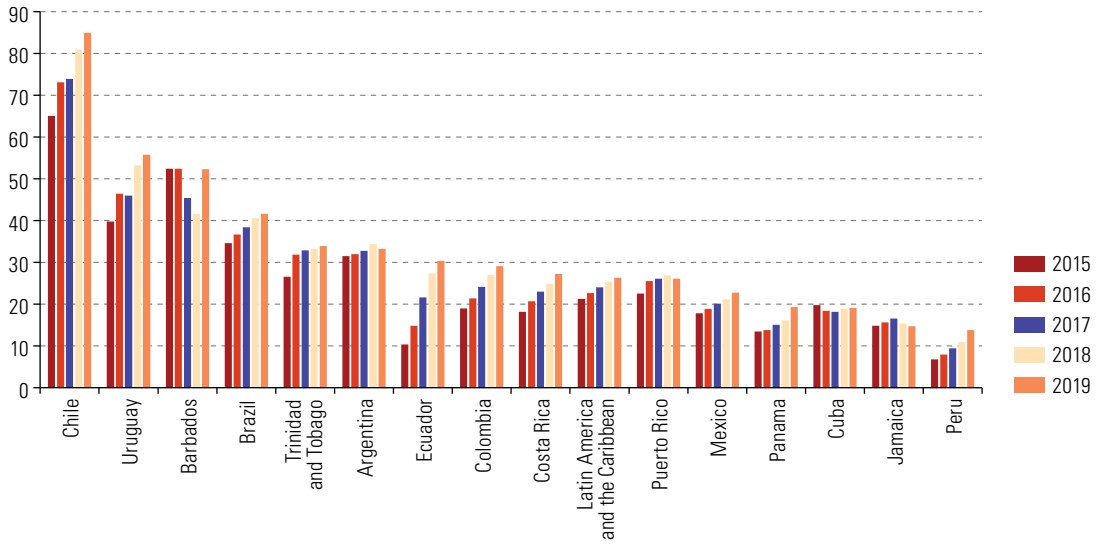
According to RICYT, scientific output in Latin America and the Caribbean, measured on the basis of the number of publications indexed annually, increased by almost 29% between 2015 and 2019. Moreover, the participation of Latin American countries in the total number of publications worldwide experienced significant and sustained growth over the last decade, growing from 3.85% in 2019 to 5.02% in 2019.

This increase in publications is consistent with the increase in the number of researchers and with the fact that these researchers are generally employed in universities. In such cases, the performance criteria for academic work are based more on contributions to scientific publications than on application of the results of research.

Chile has the greatest scientific productivity in Latin America and the Caribbean relative to the number of inhabitants and GDP. Trinidad and Tobago, meanwhile, appears the most productive when compared on the basis of R&D expenditure. The number of publications on Scopus per 100,000 inhabitants shows a similar development (see figure I.8).[2]

[2] Scopus is a database containing the bibliographic data of scientific journals, published by Elsevier.

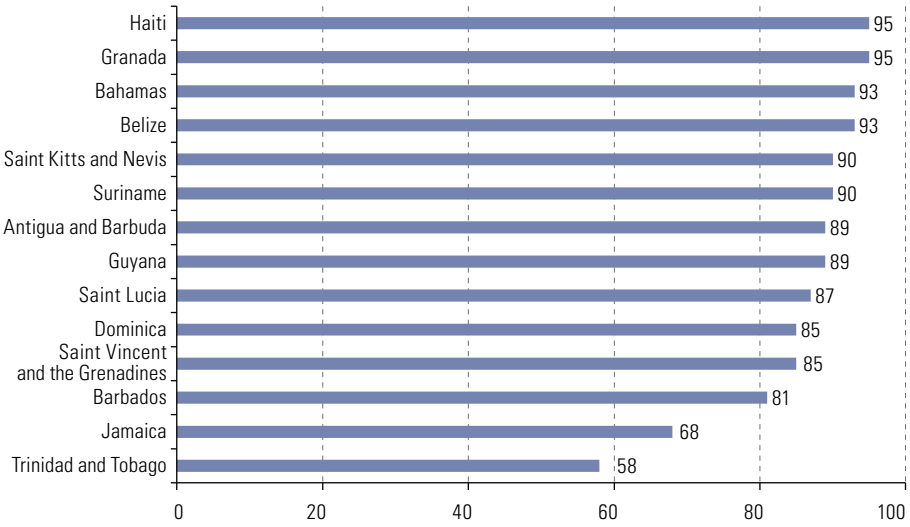
Figure I.8
Latin America and the Caribbean (15 countries): publications on Scopus per 100,000 inhabitants, 2015–2019



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.
Note: The data for Latin America and the Caribbean are estimates.

The scientific communities of various Latin American countries have made progress in their international relations in the five-year period from 2015 to 2019, reflecting the significant increase in the number of publications produced as international collaborations by researchers in the region. For example, in a number of Caribbean countries, publications with foreign co-authors account for over 85% of the total (see figure I.9).

Figure I.9
The Caribbean (14 countries): participation in publications with foreign co-authors, 2017–2019
(Percentages)



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), UNESCO Science Report 2021. The Race Against Time for Smarter Development, S. Schneegans, T. Straza and J. Lewis (eds.), Paris, UNESCO Publishing.

6. Non-residents dominate regional patent applications

Over the last decade, there has been a significant increase in patenting activity around the world, with the number of patent applications growing by 64% between 2010 and 2020. However, Latin American and Caribbean countries have not followed this trend. The region recorded a lower level of patenting and, as a result, its share of the total number of patent applications worldwide decreased from 2.8% in 2010 to 1.6% in 2020. The geographic region with the highest number of patent applications is Asia, with 66.6% of the total and an increase of 15 percentage points since 2010 (see table I.1).

Table I.1
Patent applications, 2010 and 2020
(Number of applications and percentages)

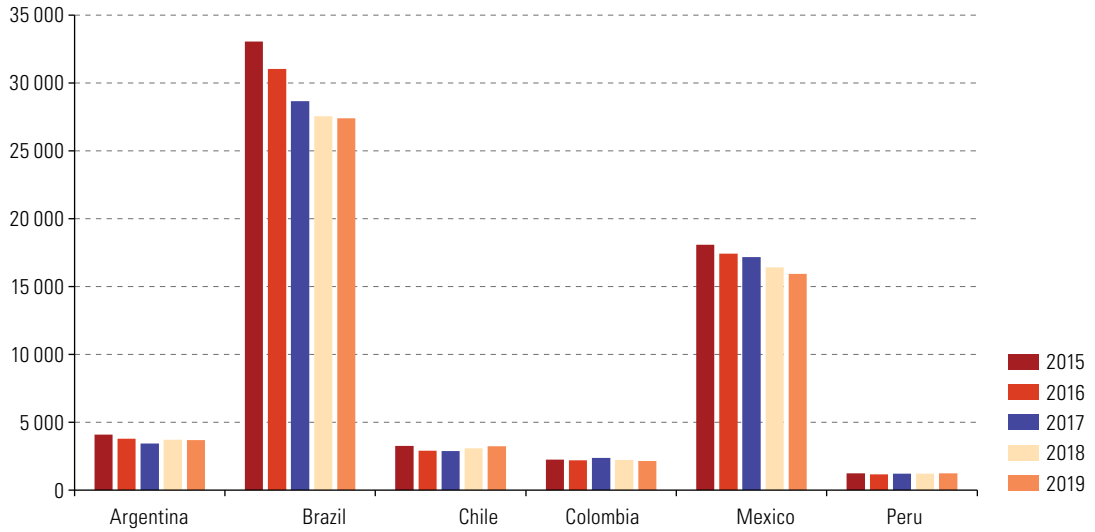
Region	Number of applications		Share of residents (percentages)		Share in the total (percentages)	
	2010	2020	2010	2020	2010	2020
Africa	12 700	16 400	15.7	20.7	0.6	0.5
Asia	1 028 700	2 183 400	73.5	82.9	51.5	66.6
Europe	343 300	357 900	64.8	57.8	17.2	10.9
Latin America and the Caribbean	55 400	52 200	11.7	16.3	2.8	1.6
North America	525 700	631 700	46.9	43.4	26.3	19.3
Oceania	31 600	35 100	12.7	7.7	1.6	1.1
World	1 997 400	3 276 700	61.9	70.3	100.0	100.0

Source: World Intellectual Property Organization (WIPO), World Intellectual Property Indicators 2021, Geneva, 2021.

The patent offices of Brazil and Mexico are among the biggest in the world in terms of the number of patents filed and granted. In 2020, Brazil received 24,338 patent applications and Mexico received 14,312, with the two countries therefore accounting for 74% of the region's patent applications. Patenting activity in both countries has slowed down in recent years, explaining the reduction in the average number of patent applications in the region (see figure I.10).

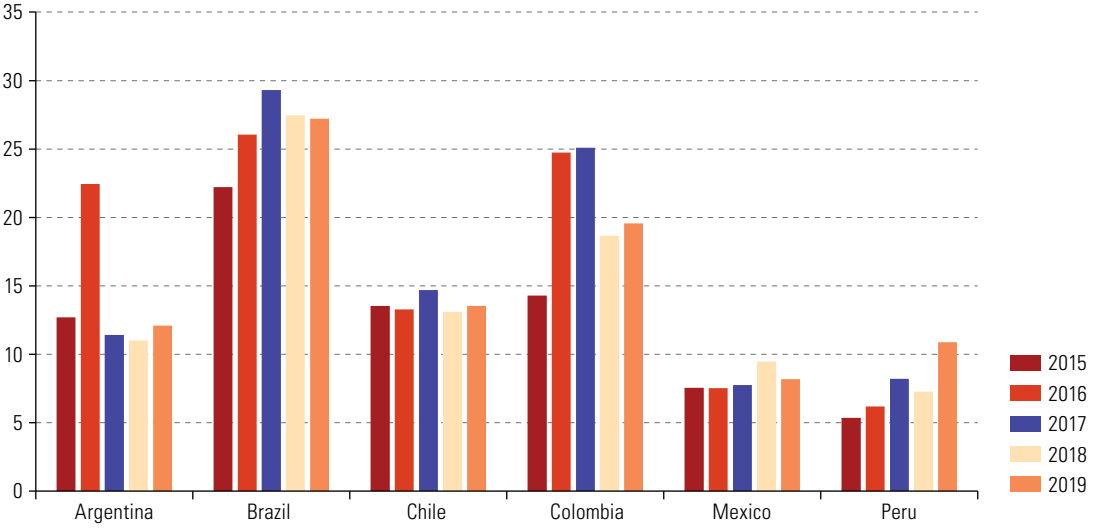
On the other hand, a feature that distinguishes Latin America and the Caribbean from more developed countries, and from some emerging countries such as China, is that non-residents are largely responsible for patent applications and approvals. In 2020, in Europe the applications filed by residents represented 57.8% of the total, with that figure rising to 82.9% in Asia. By contrast, in Latin America and the Caribbean, only 16.3% of applications were made by residents, although this was an increase on the figure of 11.7% recorded in 2010. In 2020, 78.3% of applications in Brazil were made by non-residents and 92% were made by non-residents in Mexico. In both cases, the United States is the main country of origin of applicants, accounting for 29.2% of applications made in Brazil and 43.4% of those made in Mexico (see figures I.10 and I.11).

Figure I.10
Latin America and the Caribbean (6 countries): patents filed, 2015–2019



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.

Figure I.11
Latin America and the Caribbean (6 countries): patents filed by residents, 2015–2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) [online] http://www.ricyt.org.

B. Science, technology and innovation policies

This section provides a short overview of the policies and instruments put in place in recent years by countries in the region to support science, technology and innovation.

1. Despite progress, institutional weaknesses remain

There has been significant progress in recent years as regards public institutions aimed at supporting science, technology and innovation. The position of these public institutions has been strengthened, in particular in countries where relevant ministries have been established. In 13 of the 21 countries analysed, there is a ministry, body with ministerial status or body under the executive branch that is responsible for science, technology and innovation policies.[3]

Analysis of science, technology and innovation institutions reveals several shared features, which are described in the following sections.

(a) Science and technology budgets have been cut

There is a minimum amount of resources required for any institutional model to be implemented effectively. Despite the enhanced institutional status of science, technology and innovation in the region, in several countries this has not been matched by budgetary increases and, in some cases, there have even been cuts.

There may be multiple reasons for this, but a reasonable hypothesis would be that it is the product of a financial landscape characterized by stagnating income.[4] This situation, alongside growing spending on responding to social needs and, recently, confronting the COVID-19 pandemic, would have chipped away at the available resources for science and technology budgets.

(b) A lack of continuity caused by political cycles

It is normal to see significant changes in policy priorities and positions as a result of the administrative changes of new governments. In fact, the radical changes introduced by every new government create uncertainty for private sector actors, undermining investor confidence (UNESCO, 2021). This inability or unwillingness to maintain certain policies over time reinforces the short-term tendencies of the region's business community.

(c) Implicit and explicit policies

When we talk about public policies on science, technology and innovation in the region, we do not always mean explicit policies established in a formal document. Often we mean a set of different kinds of measures that have been adopted by governments. Some are related to institutional frameworks, while others to financing modalities for science, technology and innovation or other support instruments that have been implemented. As a whole, these different measures are implicitly considered to be sectoral policies. On many occasions, the public instruments applicable in this area must be reviewed to determine which policies are in force.

2. Competitive subsidies are the dominant instruments

The most common mechanisms or instruments for supporting science, technology and innovation in the region are allocating subsidies, generally on the basis of the competitive funding model, and supporting the training of human resources via grants for further study. New instruments are also being implemented, albeit in a much more heterogeneous fashion (see table I.2). The instruments have primarily been organized around a demand-based model. According to this model, the most reliable sources for identifying research and innovation projects are researchers, in the case of science and technology, and enterprises, in the case of innovation. As these actors are forced to deal with market shortcomings that make it more difficult to carry out their projects, grants awarded on the basis of competitions or calls for bids organized by specialized public

[3] The countries with Ministries of Science and Technology are Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Jamaica, Trinidad and Tobago and Venezuela (Bolivarian Republic of). Moreover, the new President of Peru has announced the creation of a Ministry of Science and Technology.

[4] There was a slightly positive development in the Caribbean over the same period (ECLAC, 2020).

agencies have become crucial policy instruments. Under this mechanism, the role of agencies tends to be limited to project administration and follow-up, which is essential from a financial perspective.

Table I.2
Latin America and the Caribbean: main instruments used to promote science, technology and innovation

Instruments	Number of countries that have instruments in this area
Research and development funding	
Funds to promote research in science and technology	17
Teaching incentives for research in science and technology	6
Funds to improve equipment and infrastructure	6
Funds to create clusters, technology hubs and business incubators	5
Training	
Grants for undergraduate, postgraduate and postdoctoral study	16
Programmes to create and support postgraduate courses	8
Support for business innovation	
Funds to promote innovation and the competitiveness of businesses	19
Tax credit for research and development	9
Credits to scale innovation projects	2
Technical training programmes	11
Support for entrepreneurship	
Programmes to support entrepreneurship	9
Promotion of priority areas	
Programmes in priority areas	12
Sectoral funds	6

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT), "Políticas CTI. Policies on Science, Technology and Innovation in Ibero-America" [online] http://www.ricyt.org, from a total of 21 countries and information from national sources.

(a) Funding for research in science and technology

In order to finance R&D projects carried out largely in universities and public research centres and aimed primarily at basic and applied research, most countries in the region have competitive research funds. The allocation of funds is guided by criteria for research excellence. As a result, the portfolio of projects chosen does not necessarily align with any kind of national priority or with criteria relating to social or economic impact. However, in some cases, in order to account for obvious national needs (such as those arising from the COVID-19 pandemic) or to develop capacities in emerging technologies, countries call for proposals relevant to priority areas.

Some countries, such as Argentina and Mexico, complement these programmes with funding lines and funding for research careers and research equipment. Public research institutions exist in some countries, although this has not been a recent trend. Moreover, there are signs of the adoption of financing mechanisms for long-term research programmes with larger budgetary frameworks or based around national challenges, which are also allocated through competitive processes. These instruments, used primarily by universities and researchers, bring together a substantial part of the public resources intended for implementation in R&D.[5]

[5] Statistics from the OECD Main Science and Technology Indicators portal indicate that, of the public budget allocated to R&D in 2018 in Argentina, Chile and Mexico, 38%, 55% and 61% respectively was spent in higher education institutions. In the case of Argentina, this figure does not include the budget of the National Scientific and Technical Research Council for the salaries of researchers working in universities. On average, more than 70% of university expenditure is allocated to basic and applied research.

(b) Training human resources

Given the significant shortage of available staff specialized in research, a growing number of countries have established grant programmes for study abroad. They have also made efforts to develop postgraduate training programmes at the local level and initiatives that contribute to strengthening national innovation systems in the medium and long-term.

(c) Support for business innovation

At present, 19 of the 21 countries analysed (RICYT, n/d) already have some type of instrument to support business innovation. The most widely used mechanism is competitive funding that, alongside non-refundable resources, jointly finances R&D projects presented by companies. In general, this involves horizontal funding with no sectoral or thematic priorities and allocated on the basis of criteria such as the degree of innovation of the project and its expectations of financial sustainability. In some countries, such as Argentina, Chile and Uruguay, funds or competitions have been established with sectoral or thematic focuses.

In addition to this, there are at least nine countries that have established tax incentives for R&D in various forms.[6] Tax credits are the quintessential horizontal instruments for promoting innovation at the company level, and make it possible to redeploy non-reimbursable funds towards promoting innovation in a more focused manner (OECD, 2021).

(d) Promoting innovative entrepreneurship

Another line of instruments that has expanded in Latin America and the Caribbean over the last decade relates to the promotion of innovative entrepreneurship. This includes numerous means of support, such as seed capital, promotion of venture capital, access to business incubators and project accelerators, and business and financial training (OECD, 2017). Relevant results can already be seen in countries where such programmes have been implemented and a significant number of the above instruments have been established, taking into account the multiple obstacles to dynamic entrepreneurship.

C. Rethinking the strategic role of science, technology and innovation

The review and analysis presented in the previous sections allow us to highlight various distinctive features of the region's innovation systems and lead us to reflect on the strategic role of science, technology and innovation policies. Institutional changes have been introduced in various Latin American and Caribbean countries, which has enabled the creation of relevant ministries or other high-level political institutions. However, these new entities have not yet led to science, technology and innovation playing a more active role in productive and social development policies, or only to a limited extent.

There is still a certain predominance of basic science compared to applied science and experimental development. Latin American countries tend to prioritize support for research conducted in universities and research institutes, entities focused on conducting basic research and, to a lesser extent, applied research. To that end, there are relatively established instruments that channel a significant proportion of public expenditure for research and development towards those entities. Evidence of this is the clear increase in the number of scientific publications in recent years, even as patent applications and acquisitions have decreased. This situation is confirmed by the relative stagnation of business participation in financing and carrying out R&D activities in the region.

[6] At present, there are tax credit instruments for R&D activities in Argentina, Brazil, Chile, Colombia, Jamaica, Mexico, Peru and Uruguay.

Until now, governments' public support model for science, technology and innovation has been based on market logic dominated by demand for resources and where there is little coordination or direction within research. For decades, public activity has been focused largely on providing scientists and enterprises, respectively, with subsidies for research and innovation. However, the allocation of these resources has not been defined, casting doubt on the effectiveness of this strategy.

The combination of policy instruments to support innovation seems incomplete and insufficient for bringing about major change in these areas at the regional level. There are some factors specific to the economic environment that may inhibit business innovation. Moreover, the lack of support, such as credit for innovation and innovative public procurement, available in many OECD countries, limits the possibilities for enterprises to take on innovative projects.

The existing mechanisms for determining the direction of science, technology and innovation initiatives work against capacity-building and addressing major national challenges. Demand-driven, competitive funds are widely and almost exclusively used. This is based on a paradigm that works on the assumption that the most reliable means of identifying which research and innovation projects a country should carry out are researchers, in science and technology, and companies, in innovation. Consequences of this paradigm are: (i) underfunded projects, very few of which make it to the market introduction stage, affecting their socioeconomic impact; (ii) wide dispersal of research and innovation projects, which hampers the formation of critical masses of researchers and research-intensive enterprises and limits the shared learning and competitiveness of countries; (iii) de facto prioritization of short-term projects unable to address some national strategic development areas (this situation is exacerbated by successive governments with different political leanings); and (iv) research areas linked to national challenges that have not been sufficiently addressed because they do not align with the capabilities or priorities of researchers and enterprises.

In recent years, Latin American policymakers have started to confirm that science, technology and innovation are not separate from other areas of concern to governments and society in general. Addressing many challenges facing societies in the region, in both the public and private spheres, requires a scientific and technical approach as the problems in question are becoming increasingly complex. This necessarily involves targeted public support in science, technology and innovation (or, at least, a part) for areas of knowledge related to the main challenges confronting each country. As a result, belief in the critical role of public policies in supporting these activities is becoming more widespread. In particular, public policies may influence the focus and direction of private efforts in this area, especially in addressing issues when market signals are insufficient and coordination is more challenging.

Although with a more limited scope, this reality had long been recognized by many industrialized countries. Without mentioning it explicitly, these economies were developing industrial policies aimed at sectors they wished to protect or boost. One example of the growing trends in the period prior to the ongoing COVID-19 crisis was the involvement of OECD member States in the progressive rehabilitation of industrial policy from an innovation perspective. They relied on the argument that governments should participate actively in decision-making explicitly related to the direction of innovation policy in order to make the best use of their limited resources (OECD, 2021).

The efforts of traditional industrial policy were aimed at sectors of economic activity to be promoted. In contrast, current trends (primarily in more advanced countries and more cautiously in Latin America and the Caribbean) look to address the main economic, social or environmental challenges facing a given country by mobilizing productive, technical and knowledge-related capacities to overcome them. It should be borne in mind that in addressing these challenges, the country strengthens its national innovation system and its productive capacities. This is a new kind of industrial policy, no longer based around production sectors but around problems or challenges. From this perspective, an automatic causality between the development of the basic science and its subsequent industrial applications cannot be expected as these may be very different. It prioritizes support for research (especially applied research) that allows progress to made towards resolving a particular challenge. This being said, science can always bring surprises or serendipitous occurrences that open new doors in the search for knowledge.[7]

[7] The scientific or technological answers needed to address these challenges will not necessarily come from R&D initiatives developed in the country, and in many cases it will be necessary to turn to solutions developed elsewhere.

Some Latin American and Caribbean countries have started to explicitly incorporate this focus into their medium and long-term innovation strategies. Colombia, for example, launched a "Mission for the Wise" ("*Misión de sabios*") in 2019. In its final report, *Misión de Sabios: Colombia-2019*, it identified three major challenges for the country and five ways of addressing them (Government of Colombia, 2019). Similarly, Mazzucato and Penna (2016) described the Brazilian research subsystem in the field of health as one of Brazil's islands of productive excellence. This makes it particularly well-suited to mission-driven policy initiatives, either explicitly or implicitly focused on innovation. However, these authors warn that this subsystem has lacked a long-term strategic agenda and that its self-direction, alongside the lack of demand for knowledge from the industrial subsystem, reveals the fragmentation of system. In Chile, the National Green Hydrogen Strategy was recently launched; this has the hallmarks of a public policy aimed at a specific task, although it is only in the preliminary design stage. Moreover, through its Science Ministry, the Government of Chile has decided to earmark part of its public budget for what it has termed "R&D targeting national challenges", namely, climate change, the technological revolution, biological challenges (such as the ongoing pandemic) and social crises.

One of the characteristics of this new focus is the necessary coordination between different actors, and especially between the government, academic and business sectors. Innovation is becoming a policy area involving all areas of government, which calls for new institutional arrangements that facilitate coordination and the strengthening of capacity-building and policy management.

The COVID-19 pandemic, and all the problems it has caused around the world, has also provided an opportunity to apply this approach. The pandemic has also required governments to adopt more comprehensive strategies in order to address it, not only in terms of its immediate impacts, but also in terms of strategies intended to prevent the recurrence of such a phenomenon in the future (see chapter II).

Everything in this chapter illustrates that the dynamism of technical change processes and the emergence of new national challenges (shown by the appearance of COVID-19 and the hazards arising from global warming) require the continuous review of the areas addressed by the country's researchers and innovators, as well as monitoring of the effectiveness of the available instruments and the need to develop new ones.

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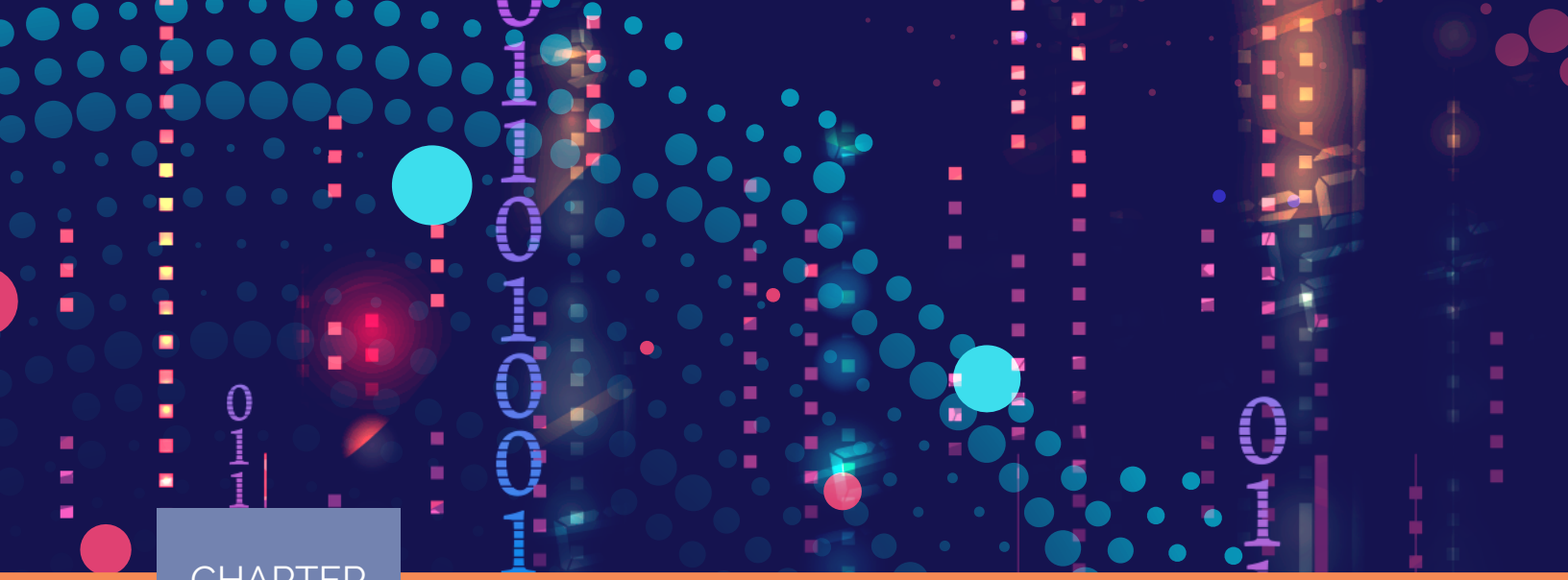


CHAPTER

II

Using science and innovation to revitalize the health industry in Latin America and the Caribbean

The health manufacturing industry, comprising the pharmaceutical and medical device industries, plays a vital role in modern economies as a provider of goods and services for economic and social well-being. Now more than ever, this industry is being prioritized as a strategic sector in both high-income and emerging countries for three main reasons: firstly, it provides goods and services intended to improve living conditions and human health; secondly, it creates high-quality jobs with strong productive links to the rest of the economy; and thirdly, it drives technical progress through its high research and development (R&D) intensity and significant knowledge-related output.

The COVID-19 pandemic and the disruption it caused to supply chains revealed the weaknesses in this industry at the regional level. They contributed to the recognition of this industry's high level of dependency on multinational companies and the urgent need to strengthen its scientific, technological and productive capacities to develop local industries that are more resilient and self-sufficient, and able to confront future health emergencies.

This chapter begins by describing the health industry at the global and regional levels, before turning to the main components of the innovation system in which it is embedded. It then reviews the innovation policies that concern this industry, as well as the scientific and technological responses to the pandemic. It concludes with the proposed lines of action both at the national level and as part of regional collaboration efforts.

A. The health industry at the global and regional levels

Over the last quarter of a century, the global configuration of health-related industries has undergone significant transformations. Among other things, these transformations have been driven by demand that has increased in line with the growth of income per capita in developing countries and with the increasing use of generic products associated with the expiration of patents on a large number of highly effective medications. In addition, promising avenues have opened up in areas such as biotechnology, electronics and computer science; trade barriers have come down and large economies such as China and India have become major players in global trade; intellectual property models in different countries have been standardized; and policies on innovation and industry have been implemented in the world's major economies. As a result of a significant vertical disintegration process (in the pharmaceutical industry in particular), this has led to the reconfiguration of global value chains and the creation of new localization models for their various links.

1. Pharmaceutical industry

Major multinational pharmaceutical companies, whose headquarters tend to be in the United States or European countries such as Germany, France, Switzerland and the United Kingdom have continued to offer a wide range of products, but they have modified key elements of their value chain. These companies have maintained a significant emphasis on introducing new medications, primarily biopharmaceuticals aimed at high-profit markets, but they have also diversified the production sources of their active ingredients in Asian countries, especially China and India, whether in their own plants or those of third parties.

The production of generic products (both the active ingredients and medications in their final form) has been increasingly concentrated in Asian countries, primarily India and China. At present, Indian companies produce 10% of the world's medications by volume and account for 40% of the United States market for generic drugs. China, meanwhile, is the world's biggest producer of active ingredients.[1]

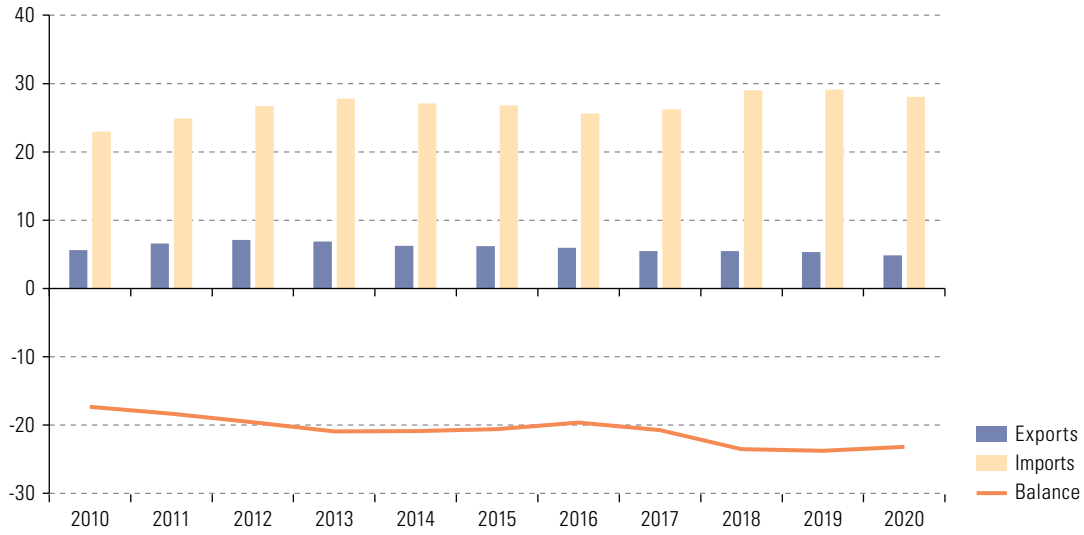
The Latin American pharmaceutical market is stocked with generic medicines produced largely by companies operating locally, as well as innovative (patent-protected) drugs that are imported and sold by multinational companies. Productive activities conducted in Latin America tend to concern the later stages in the value

[1] While there are no official figures, the estimates of the United States Food and Drug Administration suggest that between 60% and 70% of the country's supply of active ingredients come from China.

chain. They include development, manufacturing, logistics and product distribution activities involving the use of imported active ingredients, primarily from Asia.[2]

In terms of foreign trade, the region has an increasing deficit and is highly dependent on imports. Its participation in the global export of pharmaceutical products accounted for 0.7% of the total in 2020, far lower than its rate of participation in global exports of all goods (5.4%). There has been a downward trend in pharmaceutical exports since the start of the last decade and its value decreased from a maximum of US$ 7.1 billion in 2012 to around US$ 4.9 billion in 2020. In the trade of pharmaceutical products, the region is persistently in deficit and the value of its imports was six times greater than the value of its exports in 2020 (see figure II.1).

Figure II.1
Latin America and the Caribbean: foreign trade in pharmaceutical products, 2010–2020
(Billions of dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of UN Comtrade Database [online] https://comtrade.un.org/.

Intraregional trade, meanwhile, exceeded US$ 6 billion in 2012, but fell to US$ 4.808 billion in 2018. The localization model for subsidiaries of large multinational companies to supply the regional market generates trade flows between countries that are significantly smaller than the imports from outside the region. Larger countries are net suppliers of pharmaceutical products to the rest of the region, as evidenced by the regional trade surpluses of Argentina, Brazil, Colombia and Mexico. However, some small countries, such as Cuba, Panama and, to a lesser extent, El Salvador, Guyana and Uruguay, also have intraregional surpluses.

2. Medical devices

The value of the medical device industry was estimated at US$ 430 billion in 2018 (IQVIA, 2019). Global production is largely located in the United States, Europe and Japan, which were the places of origin of the world's 30 largest companies in the sector in 2019.

The market leaders are subsidies of large, knowledge-intensive multinationals, such as Johnson & Johnson, General Electric, Phillips and Siemens. These companies, after having achieved high production volumes in the market of their countries of origin, expanded their exports worldwide.

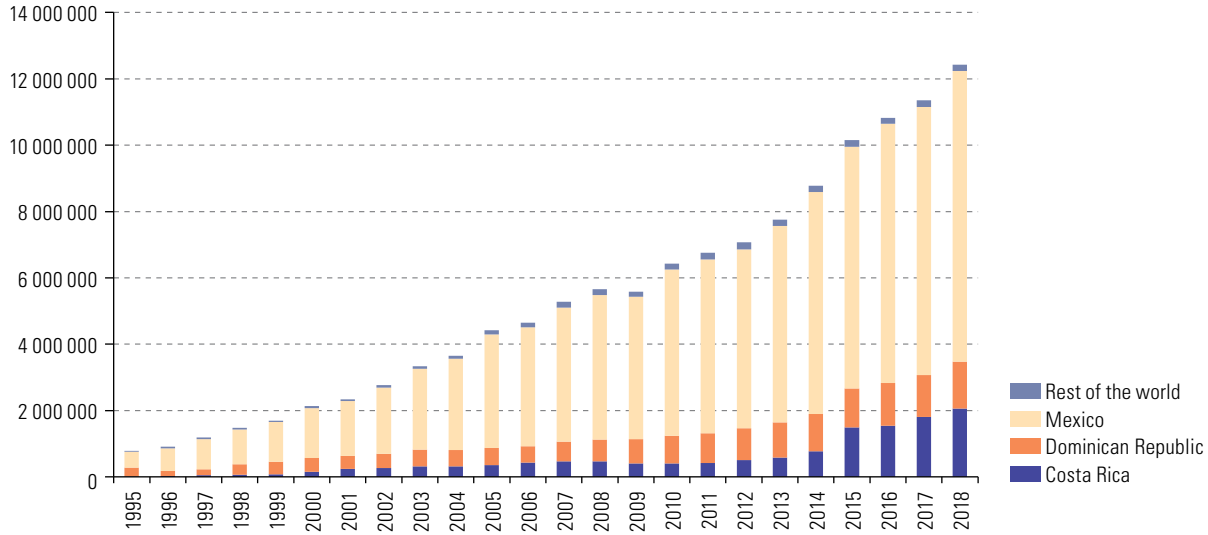
[2] Brazil, the country in the region with the greatest level of autonomy in terms of active ingredients, has a local supply rate of 23.6% (Sweet, 2021).

In contrast to the pharmaceutical industry, medical device companies have tended to keep much of their value chain localized in their countries of origin, including product manufacturing. Processes aimed at relocating certain manufacturing stages have only started to occur in the last twenty years.

The performance of different Latin American countries in the medical device industry is closed linked to their ability to insert themselves into the industry's global value chains. Most of these countries are net importers of products from high-income countries. They barely export at all, but rather satisfy a fraction of local demand with products made by small or medium-sized domestic enterprises with a low or medium level of technological sophistication. Brazil is the country with the most substantial local output and the greatest technological sophistication. This makes it an exception within the region and, seemingly, able to satisfy 50% of demand for such goods with domestic products (Drucaroff, 2021).

On the other hand, three countries in the region (Mexico, Costa Rica and the Dominican Republic) have become manufacturing hubs for multinational companies that export products, primarily to the North American market, in volumes that exceed the aggregate level of imports for the entire region (see figure II.2). It is estimated that less than 50% of the gross value of these exports corresponds to value added locally in these countries.[3]

Figure II.2
Latin America and the Caribbean: exports of medical devices and equipment, 1995–2018
(Thousands of dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), United Nations Conference on Trade and Development (UNCTAD), "UNCTAD STAT" [online] http://unctadstat.unctad.org/EN/.

B. Science, technology and innovation in the regional health industry

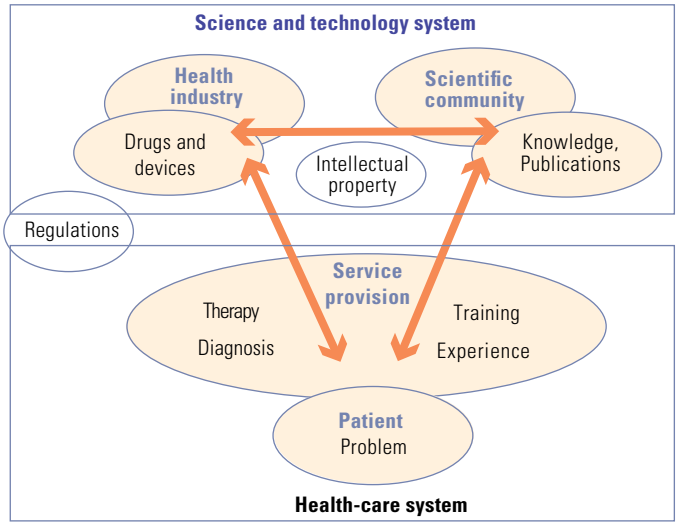
1. The health innovation system: conceptual framework

The creation of innovations in the health sector is part of a rather complex system involving interactions between many different actors. It is a highly internationalized system subject to strict public regulations.

[3] The local added value of gross exports in the electronics sector in Mexico amounted to 44.5% in 2015 (OECD/WTO, 2016).

Using the diagram by Consoli and Mina (2009) on the health innovation system, it is possible to identify two main subsystems: the science and technology system and the health-care system. The former is responsible for generating the knowledge and products that the latter must deliver to patients. The interaction between these systems is continuous and needed to create the desired innovations (see diagram II.1).

Diagram II.1
Health innovation system



Source: D. Consoli and A. Mina (2009), "An evolutionary perspective on health innovation systems", Journal of Evolutionary Economics, vol. 19, No. 2.

The science and technology system sees the scientific community converge with industry (the health industry, in this case). The scientific community brings together universities, research centres and teaching hospitals, among other entities. These institutions are usually publicly funded and generate most of the fundamental knowledge upon which later innovation efforts are based. Normally, university researchers and research teams have the freedom to choose their fields of basic research. This opens up avenues that may be used for later research aimed at developing applications and technological innovations.

The industry includes enterprises that research and develop new products and services in the field of pharmaceutical products and medical devices. This encompasses both large companies and science and technology-based start-ups. Companies, in particular large multinational ones, usually have adequate R&D structures in place. They thereby play an important role not only in developing new products based on the research outcomes of the scientific community, but also in carrying out research programmes that range from basic research to the positioning of their innovations on the markets.

A very important component of science and technology systems is protecting the intellectual property of the products created by enterprises and research institutions. In the health-care system, the new products are made available to medical centres in order to be prescribed to patients (in the case of medications) or for clinical use (in the case of medical devices). Hospitals and doctors play a key role in the innovation system by providing manufacturing companies with feedback on the performance of the new technological products introduced to their routine clinical work. Moreover, the entire innovation system in the field of health can be influenced by the way in which these new technologies are adopted. This influences the whole public procurement system for medications and medical supplies and equipment. If the State becomes a frequent adopter of innovations in the field of health, it will have a positive impact on the innovation system.

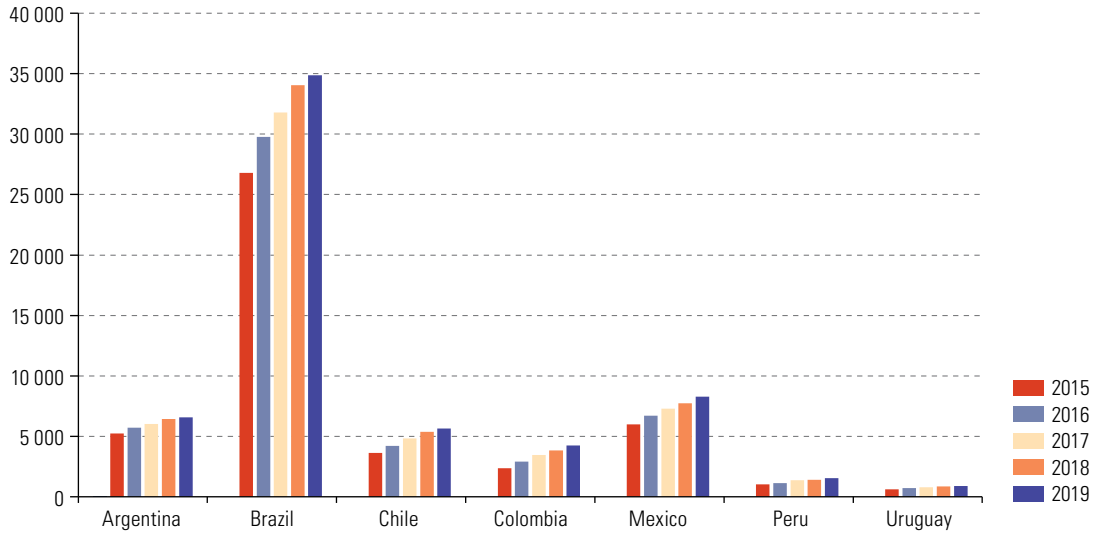
Lastly, between these two systems there are regulatory systems, which determine whether a new pharmaceutical product or medical device can be prescribed by the medical community and, ultimately, used by patients. Information obtained through clinical trials (carried out and financed by the companies) are the essential tool that health authorities need to approve new medical technologies. Such information must irrefutably prove that the new products are safe and effective and can reasonably be used to address the relevant health issue.

2. The performance of the health science and technology subsystem in Latin America and the Caribbean

The percentage of GDP earmarked for R&D in health in Latin America is much lower than in OECD countries. While there is no aggregated information for the region, according to the Ibero-American Network on Science and Technology Indicators, in 2018, for "medical science" this indicator stood at 0.063% in Uruguay, 0.065% in Argentina and 0.042% in Chile. In the case of OECD countries, it is estimated that this figure reaches levels between 0.35% and 0.5% of GDP (OECD, 2018), greatly surpassing the performance of Latin American and Caribbean countries.[4]

Medical sciences account for between 10% and 20% of the R&D expenditure of countries in the region (see chapter I). The creation of a solid base of researchers in health sciences and biotechnology has resulted in a large proportion of these funds going to universities and technology institutes. The majority of R&D activity in Latin American and Caribbean countries therefore tends to take place in universities and public laboratories, where these exist. This has led to a sustained increase in the number of international scientific publications, as shown in figure II.3.

Figure II.3
Latin America (7 countries): publications on MEDLINE, 2015–2019



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT).

Regional enterprises do not participate in the sophisticated innovation dynamics seen in developed countries and, increasingly, in countries such as China and the Republic of Korea. These dynamics include the introduction of innovative medications or devices into markets, with the aim of earning significant profits by means of patent protection.

In the case of the regional pharmaceutical industry, where the majority of pharmaceuticals produced are based on generic active ingredients, R&D activities are limited to developing medicines, conducting medical research and carrying out small-scale clinical trials to obtain authorization for their drugs on the local market.

At an aggregated level, there is also little evidence of innovative efforts in the medical device industries in the region. There are multiple reasons for this. On the one hand, multinational companies have not

[4] According to OECD (2018), in 2014, government budgets for health-related R&D in OECD countries reached 0.1% of regional GDP, alongside the between 0.05% and 0.2% allocated to university research and the 0.2% for research conducted by enterprises. On this basis, it can be estimated that between 0.35% and 0.5% of GDP is invested in health-related R&D.

established R&D units in countries where they have manufacturing plants, with such units usually reserved for their countries of origin (Gereffi, Frederick and Bamber, 2019). On the other hand, in most countries, nationally-owned companies focus their production on goods of a low or medium technological complexity, with modest R&D requirements. Lastly, an innovation model for this industry, with its significant level of integration of multiple technologies and fundamentally incremental nature, is not suited to the type of efforts made in the region's universities and basic research institutions, which is why it does not attract the attention of their researchers.

However, there are key exceptions. In Brazil, as mentioned, a relatively large proportion of the market is supplied through local production. In that country, the aggregate of companies producing medical devices and equipment has an innovation rate (defined as the number of companies that introduce an innovation into their products or productive processes on an annual basis) of 60% of more. During some periods, this rate is more than double that of the Brazilian manufacturing industry as a whole. Brazil also has a high figure for investment in innovation as a percentage of sales. This led to a slight increase in Brazilian exports in very technologically intensive areas between 2010 and 2019 (Drucaroff, 2021).

Patenting activity in health industries in Latin America and the Caribbean is focused primarily on inventions filed by international enterprises, with a very low rate of introducing local innovations. In general, this process is limited to reproducing applications already filed in other countries of origin.

In 2018, as seen in table II.1, the number of patents granted to Latin American residents in the health sector, which includes pharmaceuticals and medical technologies, amounted to only 0.52% of the global total. While there is a continuous increase in the rate of participation in the field of pharmaceutical technologies, this has only led to the granting of 314 patents, or 0.8% of the global total in 2019.

Table II.1
Patents in health-related areas worldwide and in Latin America and the Caribbean, 1980–2019

	1980	1985	1990	1995	2000	2005	2010	2015	2019
Pharmaceutical patents worldwide	7 374	9 982	9 408	12 397	14 748	21 455	29 038	38 830	39 245
Pharmaceutical patents in Latin America and the Caribbean	34	43	21	37	66	125	174	304	314
Percentage	0.46	0.43	0.22	0.30	0.45	0.58	0.60	0.78	0.80
Medical technology patents worldwide	7 177	10 678	12 865	15 206	18 592	24 573	36 499	56 486	72 152
Medical technology patents in Latin America and the Caribbean	56	33	64	39	73	247	295	213	266
Percentage	0.78	0.31	0.50	0.26	0.39	1.01	0.81	0.38	0.37
Health-related patents worldwide	14 551	20 660	22 273	27 603	33 340	46 028	65 537	95 316	111 397
Health-related patents in Latin America and the Caribbean	90	76	85	76	139	372	469	517	580
Percentage	0.62	0.37	0.38	0.28	0.42	0.81	0.72	0.54	0.52

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official information from Ibero-American Network on Science and Technology Indicators (RICYT) and World Intellectual Property Organization (WIPO), "Personal data and Privacy Policy" [online] https://www.wipo.int/ipstats/es/.

This low level of patenting is a direct result of the current disconnect between the region's research centres and companies in the sector. On the one hand, this is because there has historically been a lack of incentives encouraging universities and technological institutes to patent. On the other hand, it also relates to the positioning of the pharmaceutical companies manufacturing in the region as they increasingly specialize in generic products whose patents have expired. These companies do not usually have the capacity to make the kind of efforts needed to pursue the launch of innovative products on a global scale.

Various countries have research hubs that are not exclusively university-based. Through baseline public funding, they have been able to develop research projects with implementation plans and resources that have brought them close to the production stages. This category includes well-established public laboratories with production capacities, such as the Instituto Butantan and the Oswaldo Cruz Foundation (Fiocruz) in

Brazil, the Leloir Institute Foundation and the Dr. Carlos G. Malbrán National Laboratory and Health Institute Administration in Argentina and the Institut Pasteur in Uruguay, or private foundations such as the Fundación Ciencia & Vida in Chile.

These entities have been essential to introducing products, such as vaccines, incubating start-ups and building capacities, which has proven to be an important source of knowledge in situations such as the COVID-19 pandemic. In Argentina, Brazil, Chile and Uruguay, this type of enterprise has been created with the aim of introducing innovative products and services to the markets (see box II.1). However, many of these enterprises face major obstacles in moving towards a regular production stage or mounting international operations.

Box II.1
Argentina: domestic companies leading the way in biotechnological production

A distinctive feature of the pharmaceutical industry in Argentina at present is the presence of private companies associated with large domestic pharmaceutical groups in the production and export of biosimilar medications. This is largely explained by the early development – prior to accession to the Agreement on Trade-Related Aspects of Intellectual Property Rights in 2000 – of the manufacture and export of these products, which enabled companies and regulatory authorities to gain knowledge of an admittedly complex field. Another aspect to consider is the significant public support for basic and applied research in these fields, which has facilitated the training of highly qualified staff and the emergence (largely in the last decade) of a large number of technology-based start-ups that provide services or have been acquired by pharmaceutical groups in the country. Lavarello, Gutman and Sztulwark (2018) estimate that of the 60 biopharmaceutical companies operating in Argentina in 2015, 40 were carrying out R&D activities and 6 were manufacturing active ingredients. There was a total of 23 start-ups, created since 2000 with the support of public policies on innovative entrepreneurship. At the time of the study, these companies had not yet had any commercial output.

It is also worth mentioning the partnerships between Argentine companies and multinational enterprises to produce vaccines. This is the case of Sinergium Biotech, which has established agreements with Novartis and the Australian CSL group to produce vaccines against influenza A, with Pfizer to produce the pneumococcal conjugate vaccine and with MSD to produce the quadrivalent vaccine against the human papillomavirus. More recently, mAbxience, of the Insud Group, signed an agreement with AstraZeneca to manufacture vaccines against COVID-19.

Source: P. Lavarello, G. Gutman and S. Sztulwark, Explorando el camino de la imitación creativa: la industria biofarmacéutica argentina en los 2000, Buenos Aires, Centre for Urban and Regional Studies (CEUR)/National Council of Scientific and Technical Research (CONICET)/Editorial Libro Punto and C. Sweet, "Innovation in a time of crisis", Economic Commission for Latin America and the Caribbean (ECLAC), unpublished, 2021.

Regulatory systems are responsible for ensuring that the medications and medical devices produced or commercialized in a given country fulfil the minimum requirements for safety, quality and effectiveness. The capacities of the region's health regulators vary, however. According to an evaluation carried out by the Pan American Health Organization (PAHO) (2020), of the 33 countries in the region, 6 countries have national regulatory authorities that act as regional benchmarks, 13 have the legal foundations and organizational structures needed to form a comprehensive regulatory system, 7 have some of the necessary legal foundations and organizational structures, and the other 7 do not have these capacities. There is also a positive correlation between the size of countries and their regulatory capacity.

Despite some progress, driven, among others, by the Pan American Network for Drug Regulatory Harmonization of PAHO, insufficient coordination at the regulatory level remains an obstacle. Analysing the performance of the medical device industry in Argentina and Brazil, Drucaroff (2021) reports the unanimous judgment of producers in both countries as to the debilitating effect of the lack of an integrated strategy in the Southern Common Market (MERCOSUR) on the establishment of mechanisms for regulatory coordination between the agencies of the two countries. Efforts to accelerate regulatory harmonization appear to be essential to strengthening the innovation systems of the region's health systems.

C. Science, technology and innovation policies

Policies aimed at promoting science, technology and innovation, in a health industry context, are being added to the general science and technology policy framework in Latin American and Caribbean countries. Such policies thereby inherit existing strengths and weaknesses.

1. Support for basic research and the science and technology infrastructure

The region's countries have mechanisms to maintain and develop research capacities. These mechanisms combine continuous funding for a research base at universities or public (or recognised as of public interest) research centres with competitive funds to finance research projects.

There have been calls for proposals in life sciences in various countries in order to ensure minimum volumes of resources for this area. This is the case in Argentina (Argentine Sectoral Fund for Biotechnology), Brazil (National Council for Scientific and Technological Development -Biotechnology), Mexico (Food Safety Integral Systems) and Uruguay (Health Sector Fund - National Research and Development Agency (ANII)), among others. This constitutes progress in that it provides researchers with a greater degree of certainty of funding in their fields of interest, which enables them to take on longer-term and more expensive research projects. However, this progress does not always contribute to creating critical masses of researchers in the areas prioritized by countries, as it does not target a technological approach to specific challenges from the outset.

2. National laboratories

Some Latin American and Caribbean countries have national laboratories aimed primarily at contributing to disease prevention and control by carrying out R&D activities, manufacturing medications and vaccines, and providing technological services.

Some of them were established in the early twentieth century, such as the Oswaldo Cruz Foundation (Fiocruz) and the Butantan Institute in Brazil. Other were established later, such as the Leloir Institute Foundation in Argentina and the Bacteriological Institute in Chile. These bodies have the capacity to make important contributions to the development of vaccines and treatments against various high-impact conditions in the region. The implementation of policies to reduce State activities in a number of countries since the 1970s led to the interruption of some activities developed by these centres and weakened their capacities. Vaccine production, for example, was disrupted in many of them.[5] In other cases, such as in Brazil, research and production capacities were maintained. It is now possible to assess the impact of this decision, in view of the disruption caused by the COVID-19 pandemic, as it has allowed the country to launch a massive effort to vaccinate against the virus.

Among recent trends to strengthen permanent public research capacities, it is worth highlighting the establishment, in collaboration with the Government of France, of the Institut Pasteur in Uruguay, which provides the country with platforms in various areas of biomedical research.

3. Financial incentives for business innovation: subsidies and tax credits

In order to promote business innovation in Latin America and the Caribbean, many countries have established non-refundable financial support (subsidies) and tax credits that contribute to the partial funding of research, development and innovation projects.

[5] In 2003, vaccine production was interrupted at the Public Health Institute in Chile, successor to the Bacteriological Institute, a body that had introduced innovations of global significance, such as the Fuenzalida-Palacios vaccine against human and canine rabies.

Such instruments are the main source of support for the research, development and innovation projects of companies in the health industry in Latin America and the Caribbean. In countries such as Argentina and Brazil, which have a pool of domestic pharmaceutical and biotechnology companies, a significant amount of financial resources has been channelled towards these sectors (Lavarello, Gutman and Sztulwark, 2018).

An important aspect of these mechanisms is the establishment of funds to support innovation in the health industry. While maintaining the competitive element of the allocation process, these funds reserve resources for the exclusive use of this sector. Argentina has implemented funding for very specific purposes through its FONARSEC sectoral funds, as has Brazil, through initiatives such as Inova Saúde. In the case of Argentina, this set of policies "has provided various domestic companies with access to funding (even if partial) to develop some links in the biotechnology value chain. Although these policies were initially horizontal, the awarding of sectoral funds was creating a de facto selectivity in the country's biggest domestic biotechnology companies/groups that had clear existing organizational and competitive advantages" (Lavarello, Gutman and Sztulwark, 2018).

4. Support for innovative entrepreneurship

Support for technology-based entrepreneurship in innovation policies in Latin America and the Caribbean has significantly increased in the last decade (OECD, 2016a). Reimbursable funding, or "seed capital", that appeared in Chile (CORFO) and Brazil) in the 2000s, has been spreading throughout the continent, with, among others, EMPRETECNO in Argentina, FIT-CONACYT (Mexico), INNPulsa (Colombia) and ANII-Emprendedores Innovadores in Uruguay. This funding has found fertile ground in health industries to create start-ups, as a natural result of the increase in basic and applied research initiatives in universities and technology institutes described earlier. In Uruguay in 2020, 24% of start-ups approved by ANII fell into the category of "human and animal health (including pharmaceuticals)". In the case of Chile, a recent study (Consultora EMATRIS, 2020) recorded more than 300 recently-created technology-based companies, 16 of which were in the chemical and pharmaceutical industry, with another 39 in the health services sector, representing 18.3% of the total.

Despite these efforts, some studies on countries such as Chile (EMATRIS, 2020; Lavarello, Gutman and Sztulwark, 2019) indicate that the possibilities for the productive scaling of technology-based start-ups continue to be limited by the lack of effective financial instruments for that purpose. A significant proportion of start-ups that have been able to scale up have done so by acquiring capital in third-party countries with more developed venture capital markets or through acquisition by domestic or foreign medium-sized enterprises.

D. Science, technology and innovation in the wake of COVID-19

Faced with the unexpected disruption of the COVID-19 pandemic, the science, technology and innovation ecosystems in health systems have drawn on their capacities to contribute to the response to the crisis. Governments, through the combined efforts of public health ministries and authorities responsible for science, technology and innovation, assumed leadership for this task. To this end, they made flexible use of the available mechanisms to design and implement actions to control the outbreak, attend to those infected and make longer-term responses available to countries. The effectiveness of this approach has depended, naturally, on the quality of high-level government responses, as well as on the strength and sophistication of these ecosystems in each country.

1. Scientific guidance in policy design and communication with the public

In practically all countries in the region, specialized scientific committees or councils have been established to address the various dimensions of the crisis. The degree of uncertainty that has characterized the evolution of the pandemic, linked to the newness of the virus that caused it and its variants, as well as the lack of existing

information on its behaviour, has shown the importance of all countries having high-quality academic capacities. It has also illustrated the value of joining international networks that enable technical guidance and information to be shared in a timely manner to assist with political decision-making carrying an unavoidable level of risk.

National scientific communities have also played a very important role in disseminating information to the public on the virus and its dangers by providing trustworthy advice about how to behave in such unprecedented circumstances. Rarely have citizens of the region's countries had such regular and direct contact with scientists, which will undoubtedly lead to the social legitimization of the role of scientific communities and their contribution to society.

Also noteworthy is the inclusion of data science specialists in building databases with information updated in real time and identifying patterns and recommendations for designing epidemiological strategies.

2. Calls for innovative and entrepreneurial initiatives to tackle the pandemic

Weeks after declaring a health emergency, the authorities responsible for science, technology and innovation policy in various Latin American and Caribbean countries announced funding for projects to address the causes and effects of the pandemic. To do so, they had to amend their base models and, above all, establish accelerated mechanisms for evaluating and selecting projects, which naturally required the re-allocation of financial resources to transfer them to these proposals.

These calls for proposals took different forms and included wide-ranging competitions to finance research projects; thematic challenges to help to confront specific pandemic-related issues, such as those implemented by ANII in Uruguay; and "hackathons" to design computer programs to promote innovative, concrete solutions to specific problems arising from the crisis in countries such as Colombia, Ecuador, Argentina and Chile. It should be noted that, unlike regular calls for proposals, in this case the aim was to produce concrete results. This may have an impact on the future diversification of support for research, development and innovation in these countries, with the aim of meeting specific objectives or addressing particular challenges.

3. Accelerated development of the devices and services needed to close procurement gaps

Faced with a lack of some medical devices, such as mechanical ventilators, diagnostic tests or inputs, owing to blocked supply chains, some Latin American and Caribbean countries began to promote the development of local solutions to these needs. To that end, they held competitions aimed at research, development and innovation,[6] as occurred in the case of ventilators. They also turned to public laboratories, as with the development of antibody tests by the Leloir Institute Foundation in Argentina. In Brazil, credits for productive restructuring and the manufacture of medical devices were provided by the Funding Authority for Studies and Projects (FINEP), a public company under the Ministry of Science, Technology and Innovation (FINEP COVID-19 Emergency Actions).

Also worthy of note is the response of private enterprises that already had means of manufacturing equipment or that had technological solutions suddenly subject to increased demand, with a resulting need to increase their production capacities. This was the case for Tecme in Argentina and Magnamed in Brazil for ventilators, and for GenoSur in Chile, which produces devices to collect and transport test samples to detect COVID-19.

These and other experiences make it possible to assess the importance of local production capacities to increasing security. It is also important to take advantage of crisis situations to try out new approaches to the design and implementation of innovation policies, focusing them on the challenges facing the country.

[6] Examples of this are the challenges facing the development of serological analyses and diagnostic kits financed by ANII in Uruguay.

4. Strengthening laboratory networks to process diagnostic tests

The need to confront the pandemic effectively has created great demand for diagnostic services that work in real time. In order to meet this demand, significant efforts are needed to operationalize laboratories with the capacity to process diagnostic tests to identify the virus in asymptomatic patients.

This not only requires increased analytical capacities, as well as the nationwide expansion of a country's laboratory network in order to identify outbreaks in a timely manner and characterize their development. To that effect, governments implemented initiatives intended to provide hospitals, university centres, public research institutions and private laboratories or clinics with the capacities needed to carry out diagnostic or antibody tests in a dependable and timely manner. This enabled them to take advantage of pre-existing technical capacities and complement them with suitable equipment. Naturally, the countries with the best technological infrastructures were able to address this issue more quickly. This can be considered a warning of the need to have such capacities to at least a basic extent in order to be able to tackle health emergencies similar to the COVID-19 crisis.

5. Conducting clinical trials of vaccines against COVID-19

Various countries in the region have participated in global clinical trials of vaccines created to combat COVID-19. These countries had experience in such areas and had developed appropriate technical and logistical capacities to carry out the trials. In some cases, they also had the scientific capacities needed to analyse the results of the trials and draw conclusions. Another requirement was for the health regulatory agencies in the relevant countries to accelerate their screening processes in order to issue the corresponding approvals.

As of 27 August 2021, the region had participated in 614 clinical trials (in their four phases) and 230 observational studies related to COVID-19, or 7.6% of the global total.[7] The studies were carried out by a wide range of actors, including multinational pharmaceutical companies, university research agencies, hospitals and regional vaccine producers, which shows the breadth of experience in the region. However, in general, these studies have been small-scale and fragmented (Carracedo and others, 2020).

6. Vaccine development and production

Decisions taken during the 2000s to put an end to R&D and vaccine production activities created a capacity gap between the region and other developed and developing countries, the impacts of which were felt in the aftermath of the pandemic. In late August 2021, none of the approved vaccines on the World Health Organization Emergency Use Listing had been developed in Latin America and the Caribbean. The strategy implemented to make up for the lack of local production by procuring vaccines through multilateral arrangements, such as the COVAX mechanism and Gavi, the Vaccine Alliance, showed its limitations when Indian producers were unable to honour their delivery commitments owing to export restrictions imposed by their government. In order to address this problem, many governments have had to turn to bilateral trade agreements with various suppliers of approved vaccines. This has incurred higher costs and, even more importantly, has emphasized the limitations preventing vaccinations occurring at the pace seen in countries with research and production capacities.

In August 2021, only three countries (Cuba, Brazil and Mexico) were carrying out vaccine development projects in the clinical trial stage, although there were projects in other countries in the pre-clinical stage. In Cuba, the Finlay Institute of Vaccines and the Centre for Genetic Engineering and Biotechnology had five vaccine projects in development. Two of these vaccines (Abdala and Soberana 2) were undergoing phase 3 clinical trials. The Instituto Butantan in Brazil was conducting joint phase 1 and 2 clinical trials for its ButanVac vaccine.

[7] Data from World Health Organization (WHO), International Clinical Trials Registry Platform (ICTRP) [online] https://www.who.int/clinical-trials-registry-platform.

In Mexico, meanwhile, the company Avimex was participating in the development of a vaccine created by Icahn School of Medicine at Mount Sinai and the University of Texas that was in phase 1.

At the regional level, the production of locally developed vaccines is limited to Cuba and Brazil (Instituto Butantan). The Chinese Sinovac vaccine and the Anglo-Swedish AstraZeneca vaccine are also being produced in Brazil. In Argentina, the Richmond Laboratory is producing the Russian Sputnik vaccine and the company mAbxience is producing the AstraZeneca vaccine, which is being packaged in Mexico by the Lamont Laboratory. Lastly, the company Drugmex is producing the Chinese Convidecia vaccine in Mexico.

E. Science, technology and innovation policy recommendations to strengthen health industries

The challenge that the arrival of COVID-19 has posed for Latin American and Caribbean countries has given rise to a reconsideration of the strategic choices that many of them have made since the mid-1990s. Since then, there has been a trend to rely on external supplies as a preferred means of procuring medications and medical devices. The pandemic has led to the clear establishment of a new priority of strengthening national and regional capacities in health industries, with the unanimous approval of the member States of the Community of Latin American and Caribbean States in September 2021 of the Plan for self-sufficiency in health matters in Latin America and the Caribbean, developed and proposed by the Economic Commission for Latin America and the Caribbean (2021).

Progress towards achieving this goal of self-sufficiency in health will require major efforts at the national and regional levels. This relates to various features of the relevant industries, as mentioned above: (i) the importance of science, technology and innovation to the performance of this industry and the existing differences in available capacities in this area between countries in the region and more advanced countries; (ii) the cumulative nature of developing scientific, technological and productive knowledge, which requires consistent and long-term policy initiatives; (iii) the variety of public and private actors and knowledge institutions that interact with different objectives, which entails a continuous alignment effort; and (iv) the existence of significant economies of scale in production, which emphasizes the importance of ongoing efforts to broaden access to regional markets in order to be more competitive with large global producers.

In order to further develop innovation systems linked to health industries that contribute to national resilience in the face of situations such as the COVID-19 pandemic, it will thus be essential to combine national political efforts with collaborative initiatives at the regional level.

There is scope for making progress in implementing national innovation policies in the health industry. To that end, the following are proposed: (i) increasing public support for R&D activities; (ii) broadening the scale and timeframes of the projects undertaken; (iii) strengthening public, private or university centres of excellence; (iv) promoting connections between actors in the innovation system of the health industries; (v) improving the patenting, registration and approval processes for products and procedures; and (vi) monitoring procurement in the innovation process in the health industries.

On the other hand, the following means of strengthening regional collaboration are proposed: (i) developing innovation programmes aimed at resolving regional problems or challenges and carried out by multinational regional consortiums; (ii) boosting the educational integration process and the exchange of students and researchers; (iii) expanding and formalizing the mutual recognition of registration of medications; (iv) complementing existing capacities in countries with a regional platform for clinical trials, with the aim of strengthening shared and recognized regulatory standards; (v) regulating procurement strategies by creating a supplier database that ensures that standards are met in terms of quality, security and timeliness of supply, and suitable pricing; and (vi) strengthening regional mechanisms for the joint procurement of medications and medical devices in health emergency situations.

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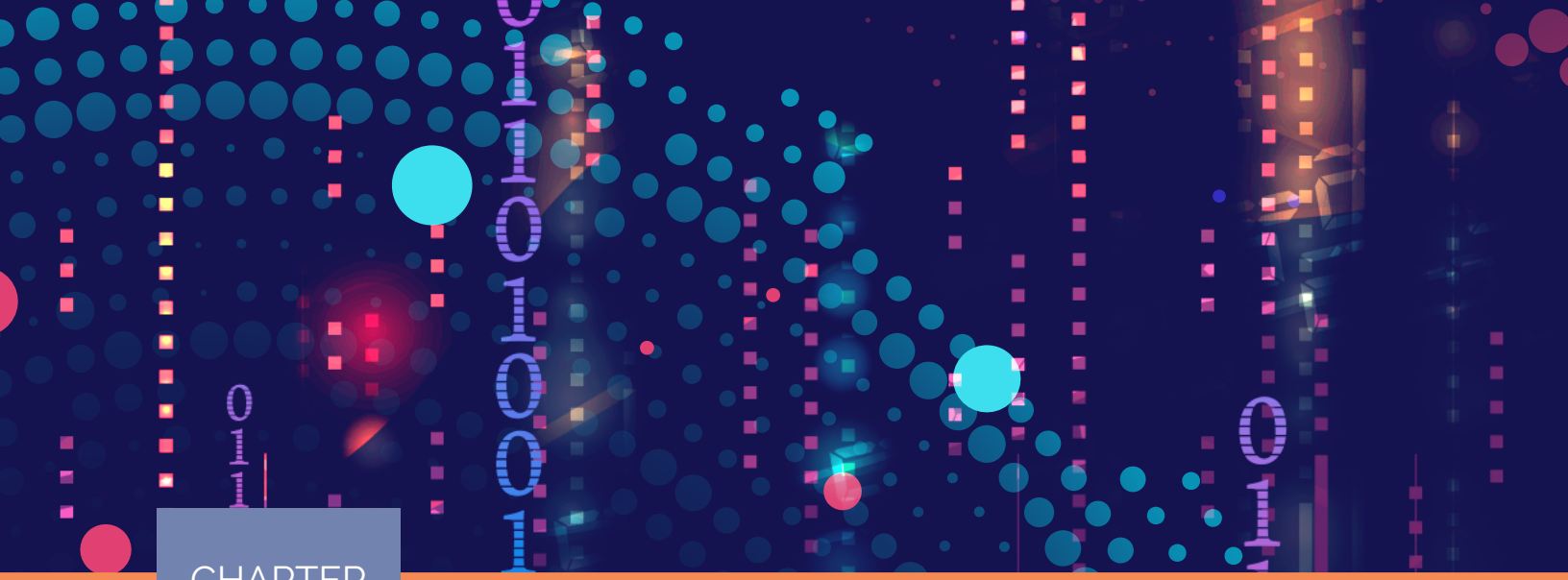


CHAPTER

III

Digital technologies for development

The digital revolution is rapidly transforming society and the economy. It is creating a new era, characterized by the transformation of models of social interaction, consumption and production. The factors underpinning this transformation include the combined adoption and integration of advanced digital technologies, such as fifth generation (5G) mobile networks, the Internet of things, cloud computing, artificial intelligence (AI), big data analysis and robotics.

Digital development has the potential to increase individual well-being, business productivity, national efficiency and effectiveness, and environmental sustainability, as a result of the synergy of its three dimensions: the connected economy, the digital economy and the digitalized economy (ECLAC, 2021a):

(i) Connected economy: this is characterized by the roll-out of digital infrastructure (including broadband networks, Internet exchange points and data centres) and the widespread growth of Internet use through various types of devices (desktop or laptop computers, tablets and smartphones), which are now joined by sensors of all kinds, marking the shift from connecting people to connecting machines.

(ii) Digital economy: this is the part of economic production derived largely from business models based around the use of digital technologies to supply goods and services (Bukht and Heeks, 2017). These digitally-enabled models change the value proposal in various economic sectors and enable data collection and creation.[1] As the data are processed and analysed using AI, it is possible to improve decision-making processes and create value by optimizing operating processes, segmenting markets, and customizing and transforming products and services.

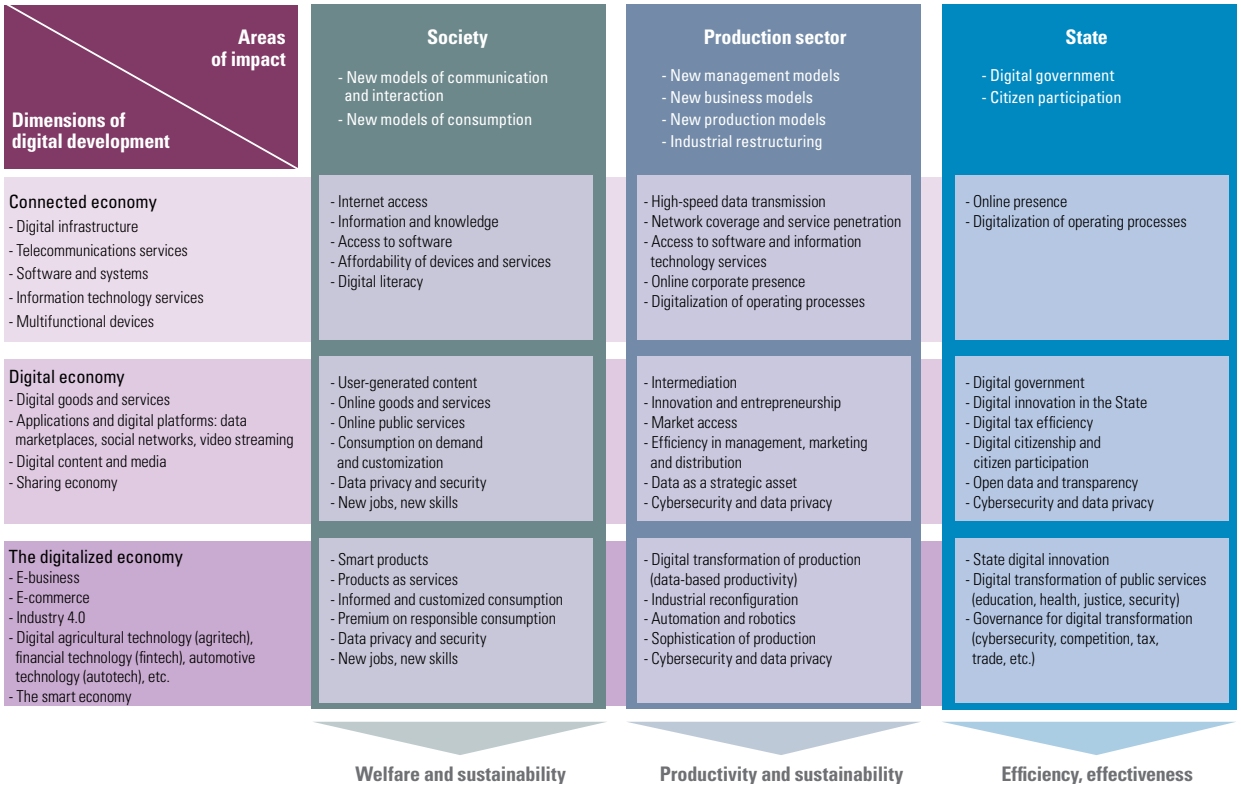
(iii) Digitalized economy: this is when, through the adoption of advanced technologies, actors in traditional industries change their business and production models, going beyond optimizing models to reconfigure their value chains and transform their products and services, with disruptive effects on industrial organization (see diagram III.1).

The impact of digitalization is neither automatic nor homogenous among different countries, enterprises and individuals. The potential benefits of digitalization in growth, well-being and sustainability will depend on factors such as the degree of technology adoption, individual capabilities, production structures and governance that addresses emerging challenges. These challenges include market concentration, cybersecurity, employment and automation, privacy, personal data security and digital taxation.

Without a comprehensive approach to digitalization, its potentially positive effects could turn negative in terms of concentration and inequality. For example, large vulnerable sections of society could miss out on various kinds of online services, or employment rates could be affected owing to a lack of digital skills. This could also widen productivity gaps between large and small enterprises, which could even limit their capacity to create commercial, technological and productive linkages. This is particularly relevant in the case of countries such as those in Latin America and the Caribbean, which are undergoing a developmental transition. During this transition, low productivity, high social vulnerability, institutional weakness and a lack of environmental sustainability remain unresolved problems that are becoming real obstacles to regional development (OECD, 2020).

[1] At present, digital platforms operate in multiple economic sectors and facilitate online purchase and sale transactions (Amazon, Alibaba and Mercado Libre), financial services (Ant Group, Avant, Mercado Pago and Nubank), communications and social networks (Facebook, Instagram and WhatsApp), tourism and hospitality (Despegar, Booking and Airbnb), the development of applications (for the Apple iOS and Google Android operating systems) matching supply and demand in employment (Laborum, LinkedIn, Workana and Freelancer), among other things.

Diagram III.1
Dimensions and components of digital development and their effects on society, the production sector and the State



Source: Economic Commission for Latin America and the Caribbean (ECLAC), Foreign Direct Investment in Latin America and the Caribbean, 2021 (LC/PUB.2021/8-P), Santiago, 2021.

A The digital transformation in Latin America and the Caribbean

The COVID-19 pandemic has accelerated the digital transformation and its mainstreaming within the economy, thereby emphasizing the link between digitalization and development. Isolation and physical distancing measures have benefited online channels in various commercial, productive and social activities. COVID-19 has highlighted the potential of digital solutions to support activities of all kinds and contribute to the exercise of fundamental rights, such as those relating to education and health. At the same time, it has demonstrated the importance of digital gaps, both between different countries and within every individual country, as determining factors in social inclusion and economic growth.

1. The external connectivity gap: a distant technological frontier

In 2020, two thirds of the population of Latin America and the Caribbean were Internet users. This is significantly less than the penetration rates of 88% in Europe and 99% in North America.

Mobile telephony is key to the widespread growth of connectivity in countries in the region. In 2020, this was the principal means of accessing the Internet, with 62% of the population using mobile Internet, compared to only 14% having fixed access. Given that unique mobile subscribers represent 69% of the

population, a figure significantly lower than that recorded in Europe, North America and China, it is urgent to pursued stronger efforts to improve connectivity (see table III.1).

Table III.1
Population connectivity indicators, 2020
(Percentages)

	Unique mobile subscribers	Internet users	Mobile Internet users	Smartphones
Europe	86	88	77	78
China	84	99	76	82
North America	83	69	67	73
Latin America and the Caribbean	69	76	62	72

Source: Economic Commission for Latin America and the Caribbean (ECLAC), Regional observatory for digital development, on the basis of GSMA Intelligence, 2021 and Internet World Stats [online] www.internetworldstats.com.
Note: A unique mobile subscriber is an individual, who can in turn account for various mobile connections (i.e. various SIM cards).

At the regional level, over 70% of connections are linked to smartphones, which enables the use of various kinds of digital applications. The adoption of this type of device is increasing rapidly as part of a global trend owing to their significant usefulness and ever greater accessibility, even as they remain expensive for a large portion of the population relative to income levels.

A key determinant of the use of digital solutions is connection speed. In many countries in the region, mobile broadband does not reach download speeds that support several data-intensive online activities being carried out at once. In July 2021, they offered a connection speed below 25 Mbps (see figure III.1). With download speeds close to 18.5 Mbps, it is possible to carry out two basic activities simultaneously, such as using email, or a single data-intensive activity, such as streaming videos or holding a video call. This requires users to choose between tele-education and teleworking, for example.

Figure III.1
Download speeds and minimum Mbps requirements for online activities, users or connected devices, July 2021
(In Mbps)

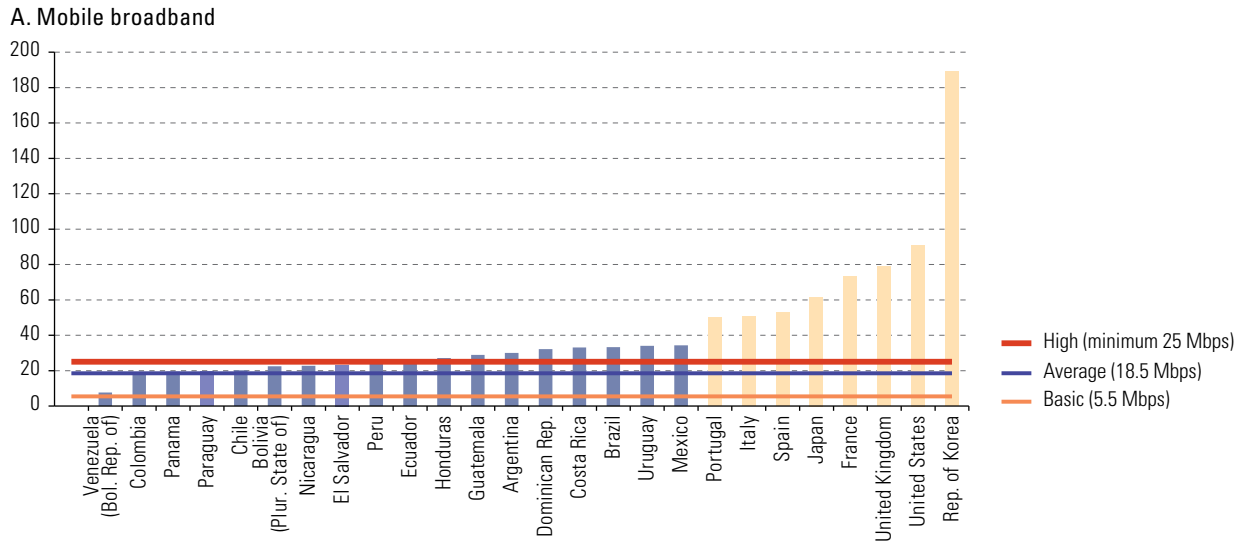
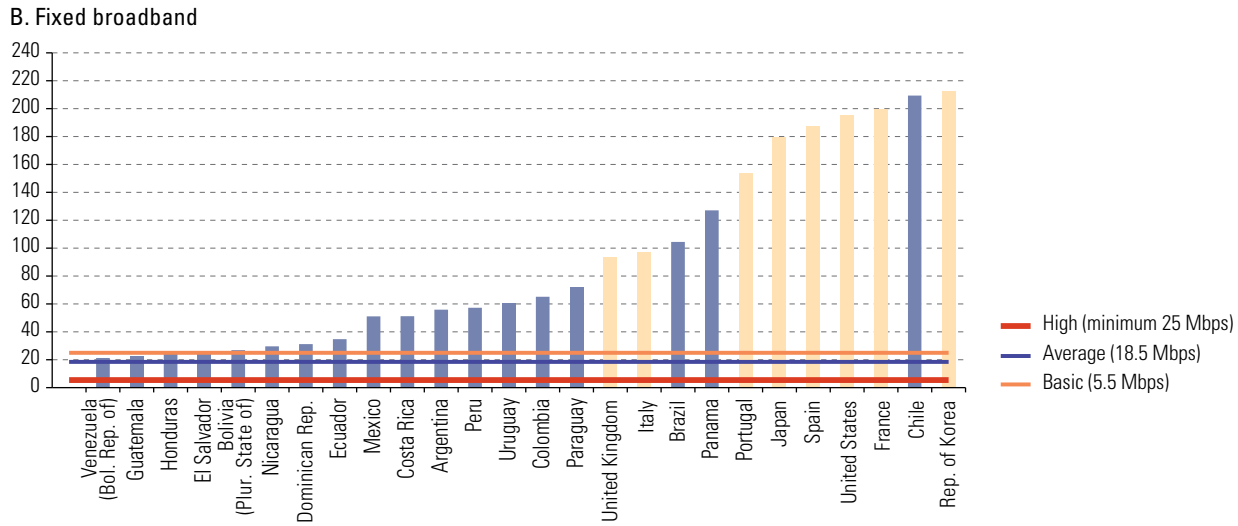


Figure III.1 (concluded)



Source: Regional Broadband Observatory, on the basis of Ookla Speedtest Global Index [online] http://www.speedtest.net/global-index.

The level of mobile broadband penetration within the population is increasing, but with download speeds that enable only average levels of use in terms of the intensity of data consumption. Mobile broadband download speeds in Latin America and the Caribbean are falling behind more advanced countries and, in most countries in the region, speeds reach around 25 Mbps, around a third of speeds in Europe and far from the more than 180 Mbps registered in the Republic of Korea. In the case of fixed connections, many countries achieve speeds similar to those of European countries, although the differential within the region is 10 times as great.

There continues to be significant heterogeneity between countries in the region in terms of the degree of penetration and the access speed. The levels of fixed broadband penetration in households illustrate the great difference between one country and another: in some countries, over 70% of households are connected, while in others the rate falls short of 25%. Mobile access enables greater service penetration in all cases and the rate exceeds 50% in most countries (see figure III.2).

Figure III.2
Latin America and the Caribbean (19 countries): Internet penetration at the population and household level in selected countries, 2020
(Percentages)

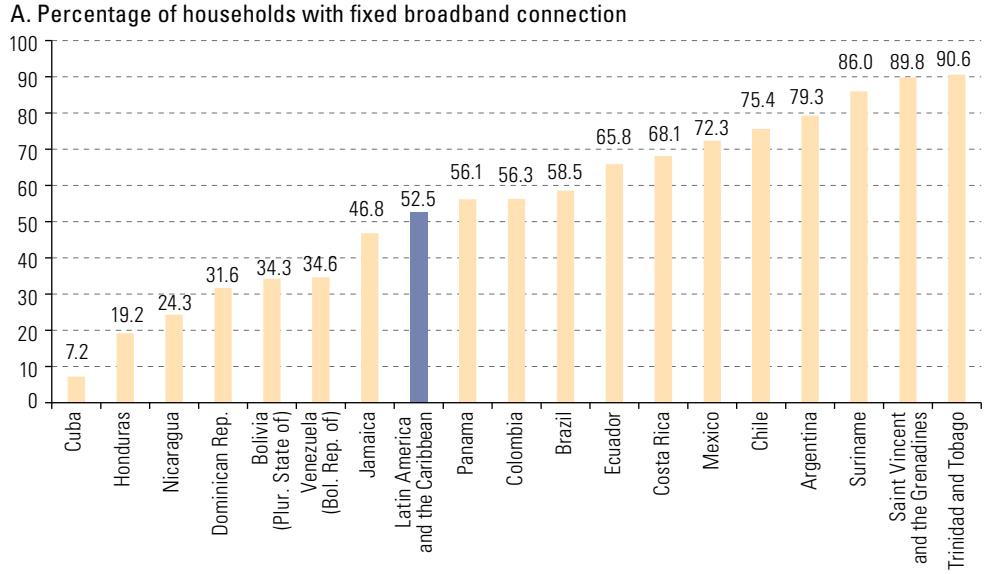
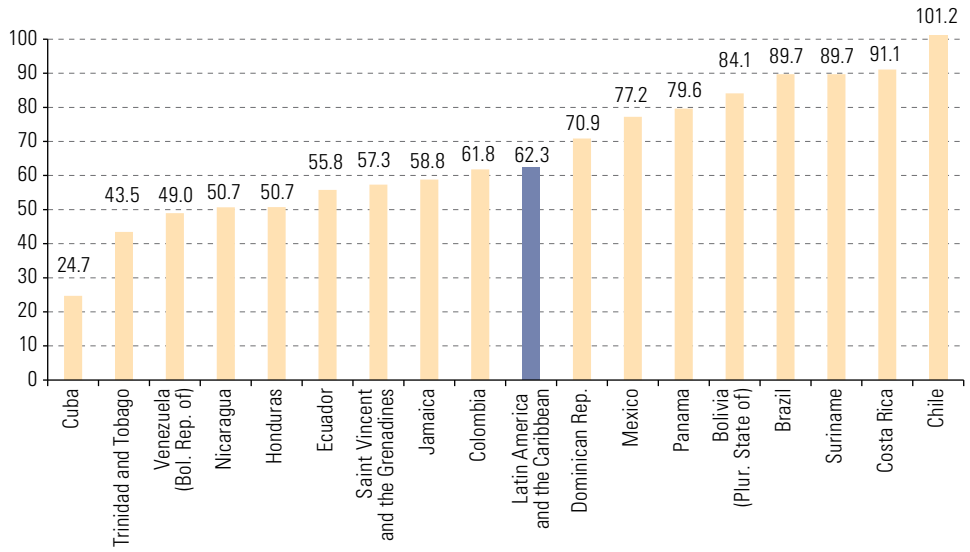


Figure III.2 (concluded)

B. Percentage of the population with a mobile broadband subscription



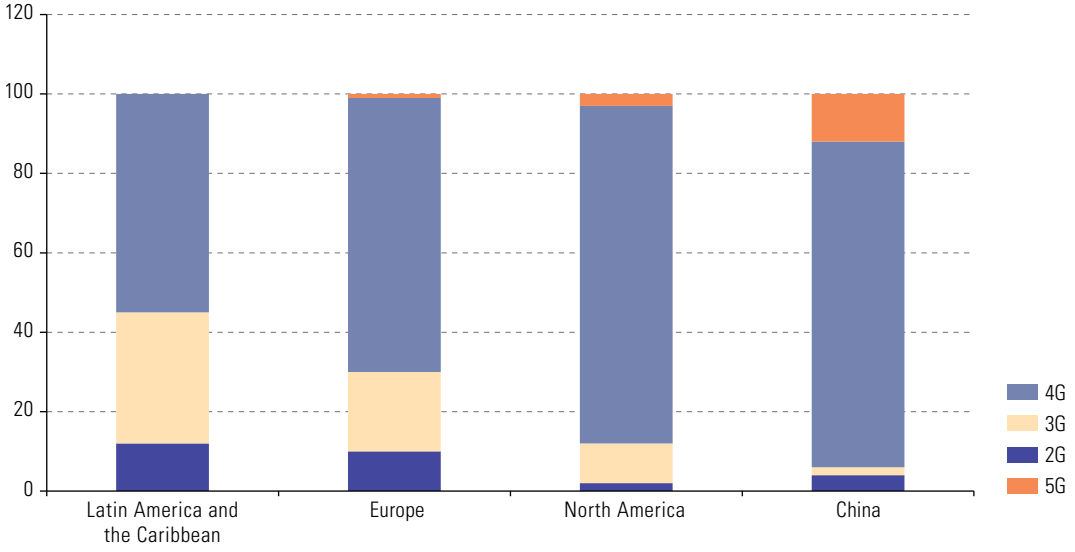
Source: Regional Broadband Observatory, on the basis of International Telecommunication Union (ITU), World Telecommunications/ICT Indicators Database, July 2021.

Progress towards a greater digital transformation in the region may be delayed owing to persistent challenges relating to the widespread growth of the use of mature technologies, such as fourth generation (4G) network technology (only 55% of mobile connections in the region are 4G), even as progress should already be being made in adopting the new technologies of the digital revolution, such as 5G and the Internet of things (see figure III.3). The adoption of 5G and its applications will be key to industry competitiveness, in particular in the mining and manufacturing sectors, and the ability to offer the cutting-edge public services associated with the development of smart cities (ECLAC, 2021b).

Figure III.3

Mobile connections by technology, 2020

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), Regional observatory for digital development, on the basis of GSMA Intelligence, The Mobile Economy 2021 [online] https://www.gsma.com/mobileeconomy/wp-content/uploads/2021/07/GSMA_MobileEconomy2021_3.pdf.

Note: Excludes licensed cellular connections to the Internet of things.

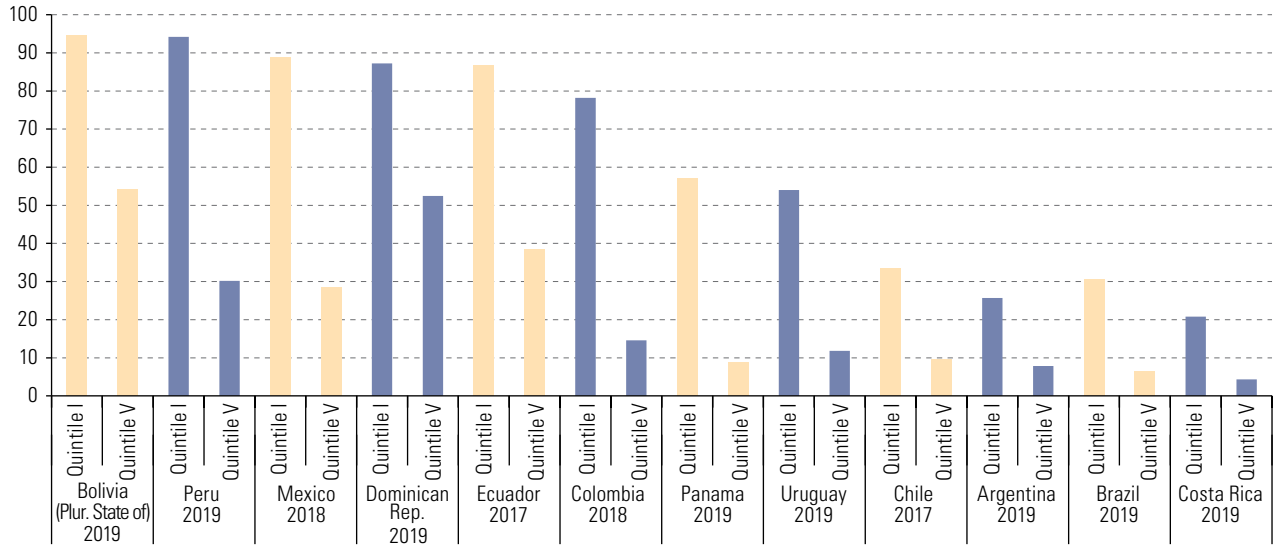
At the regional level, the first commercial services offering 5G networks in Latin America only recently became available in 2021. Progress depends not only on the plans of operating companies, but also on spectrum availability and domestic political and legal processes, as well as legal certainty, the quality of regulations and public policies. Uncertainty surrounding the demand for advanced 5G-related services also affects the roll-out.

The adoption of the Internet of things in Latin America and the Caribbean is also slower than in other regions, which is linked to its structural and productive features. In 2020, according to GSMA data, there were 13 billion recorded connections to the Internet of things, 46% of which were in Asia and Pacific, 23% in North America, 19% in Europe and 5% in Latin America and the Caribbean (GSMA, 2021a). In 2021, it is estimated that there will be more than 200 million connections in the region, 30% of which come from the agriculture, mining, oil and gas, and construction sectors (Cabello, 2021).

2. The internal connectivity gap: significant structural diversity remains

Low income levels restrict access for part of the population. In some countries in the region, the percentage of unconnected households in the poorest areas varies between 60% and 95% in the most critical cases and is around 30% in countries with better connectivity levels. The perceived lack of usefulness of the Internet and the costs of broadband services and access devices are limiting factors in its uptake (see figure III.4).

Figure III.4
Latin America (12 countries): unconnected households per income quintile, latest available year
(Percentages)

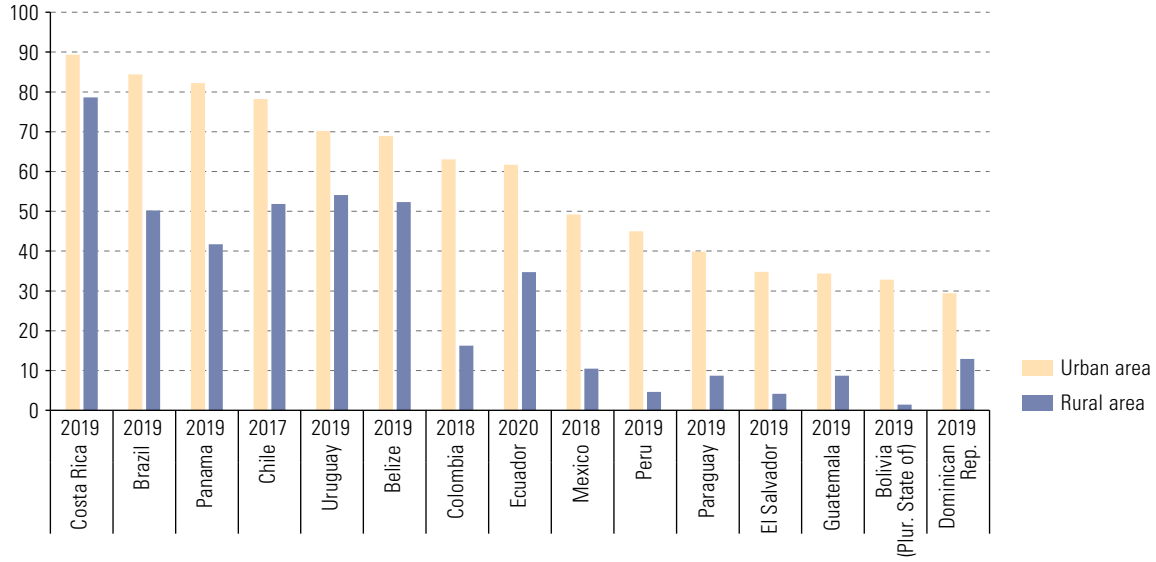


Source: Regional Broadband Observatory, on the basis of Household Survey Data Bank (BADEHOG).

The cost of effective connectivity can range from 6% to 33% of the average income of households in the poorest quintiles. Effective connectivity is understood as fixed and mobile broadband services, as well as access devices (smartphone, computer and tablet), in countries in the region.

The differences in connectivity between urban and rural areas are also significant. A total of 67% of urban households are connected to the Internet, while in rural areas the figure is only 23%. In some countries, such as El Salvador, Guatemala, Paraguay, Peru and the Plurinational State of Bolivia, over 90% of rural households lack an Internet connection. In Brazil, Belize, Chile and Uruguay, only around half of rural households are connected (see figure III.5). This has an impact on the inclusion of those living in rural areas, as well as on the productivity and sustainability of the agricultural sector, if the digital solutions being developed in that industry are taken into account.

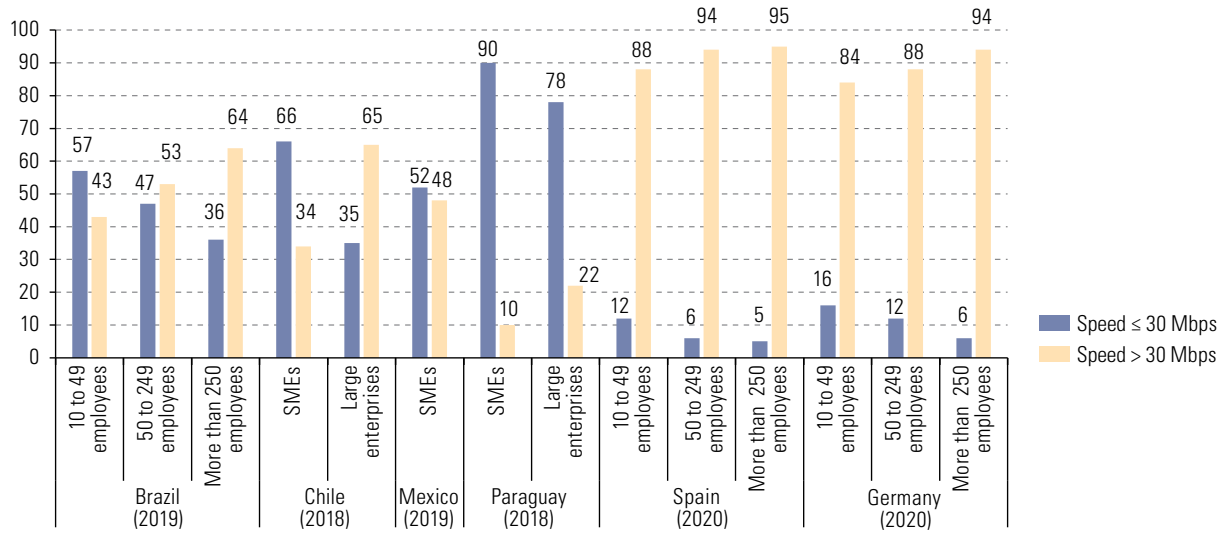
Figure III.5
Latin America and the Caribbean (15 countries): urban-rural gap in connected households per geographic area, latest available year
(Percentages)



Source: Regional Broadband Observatory, on the basis of Household Survey Data Bank (BADEHOG) and International Telecommunication Union (ITU), World Telecommunications/ICT Indicators Database, July 2021, for Belize and Guatemala.

There are major gaps between small and large enterprises in terms of broadband connection speeds and the use of advanced technologies. More than 95% of enterprises with over 250 employees and 88% of small and medium-sized enterprises (SMEs) have access to fixed broadband. However, the majority of small enterprises have access speeds lower than 30 Mbps. The proportion of enterprises with higher connection speeds is significantly larger in European countries, irrespective of the size of the company (see figure III.6). This situation affects the types of services that can be used and offered.

Figure III.6
Internet access speed in enterprises, by size
(Percentage of enterprises)

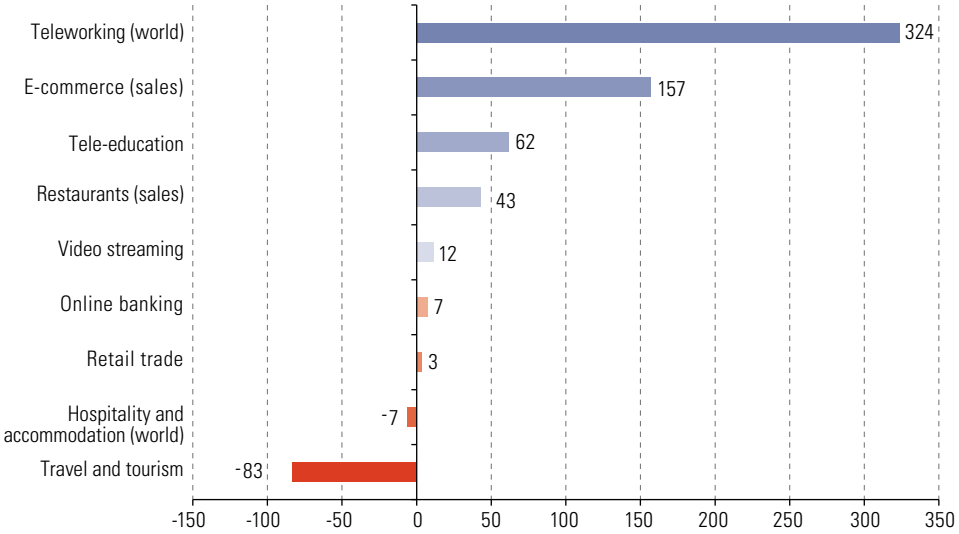


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Regional Centre of Studies for the Development of the Information Society (CETIC.br) of Brazil; Ministry of Economic Affairs, Development and Tourism of Chile; Federal Telecommunications Institute of Mexico; Ministry of Information and Communication Technologies of Paraguay and statistics from the Organization for Economic Cooperation and Development (OECD), 2021.

B. Innovative digital responses to the pandemic

The COVID-19 pandemic has imposed the need for physical distancing and, as a result, online interaction channels have been key to maintaining certain levels of activity, which has boosted the use of digital solutions. There has been a significant increase in traffic on websites and applications for teleworking, tele-education and online shopping. Between the first and second quarter of 2020, the use of teleworking solutions increased by 324% and distance learning solutions by more than 60% (see figure III.7).

Figure III.7
Latin America (5 countries): changes in activity level by sector between the first and second quarter based on website and application traffic, 2020
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), Regional observatory for digital development, on the basis of similarweb.com.
Note: The information on Latin America refers to Argentina, Brazil, Chile, Colombia and Mexico. Global data are presented in the hospitality and accommodation and teleworking categories as the relevant websites cannot be linked to users from a specific country. The teleworking sites analysed were: zoom.us, meet.google.com, teams.microsoft.com, webex.com and slack.com. The e-commerce (sales) sites were: rappi.com, pedidosya.com, glovoapp.com, cornershop.com and ubereats.com. The online education sites were: uba.ar, unc.edu.ar, Mineduc.cl, Inacap.cl, uc.cl, uchile.cl, portal.senasofiaplus.edu.co, brain.lat, unad.edu.co, unal.edu.co, unam.mx, blackboard.com, edmodo.com, brainly.com.br, brasilescola.uol.com.br, colaboraread.com.br and www.qconcursos.com. The video streaming sites were: youtube.com and netflix.com. The online banking sites were: itau.br, bradesco.br, santander.br, bancochile.cl, santander.cl, santander.ar and Banamex, bbva.mx. The e-commerce (retail) sites were: mercadolibre.com.mx, amazon.com.mx, mercadolibre.cl, falabella.cl, olx.com.co, mercadolibre.com.co, mercadolivre.com.br, olx.com.br, mercadolibre.com.ar and cotodigital3.com.ar. The hospitality and accommodation sites were: booking.com, agoda.com, Airbnb.com, hotels.com and trivago.com. Lastly, the travel and tourism sites were: airbnb.mx, volaris.com.mx, booking.com.co, avianca.com.co, latam.cl, booking.cl, booking.com.ar, despegar.com.ar, booking.com.br and latam.br.

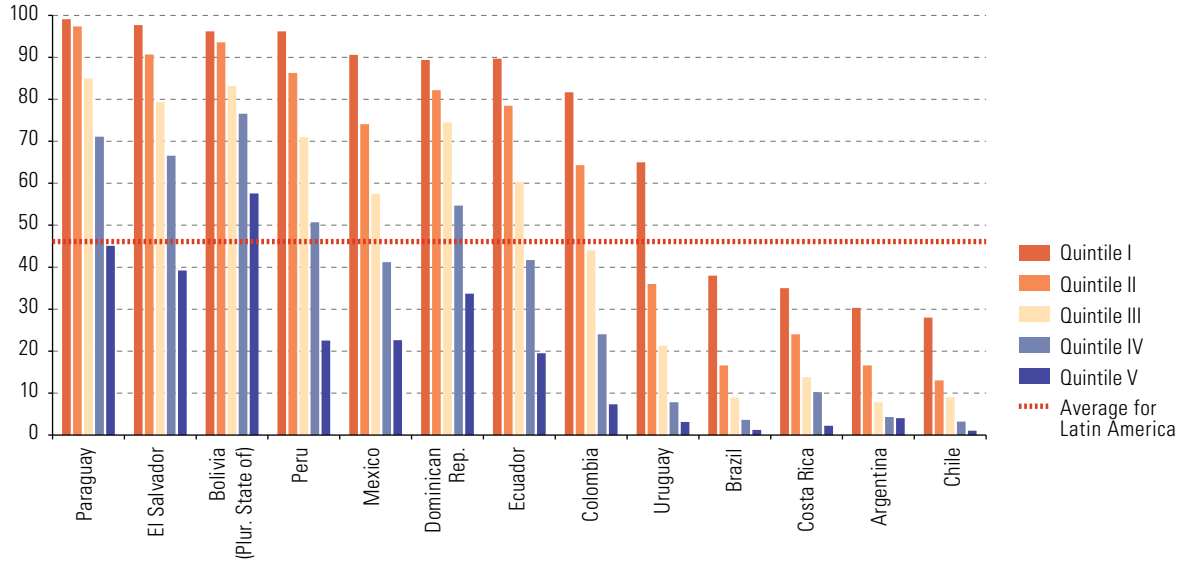
1. New options for distance learning

The COVID-19 pandemic has made it necessary to suspend in-person classes, which has accelerated the development of strategies based on distance learning solutions. The countries that had online educational content platforms focused on adapting and updating them. Others put new virtual platforms online, in some cases in cooperation with information technology companies, such as Microsoft, Cisco and Google, or multilateral organizations. In most cases, content platforms were complemented by virtual classroom solutions.

The digital gap between the richest and poorest economic groups affects the right to education and deepens socioeconomic inequalities. The use of tele-education solutions is only possible for those with Internet access and suitable conditions and devices, i.e. connection speeds that allow audio and video streaming, and screens of a certain size.

At the regional level, 46% of children aged between 5 and 12 years live in unconnected households. In El Salvador, Paraguay, Peru and the Plurinational State of Bolivia, over 90% of children in the poorest households live in unconnected households. In countries with higher connectivity indicators, around 30% of these children do not have an Internet connection at home (see figure III.8).

Figure III.8
Latin America (13 countries): children in unconnected households per income quintile, 2019[a]
(Percentages of the total number of children in each income quintile and age group in each country)



Source: Regional Broadband Observatory, on the basis of Household Survey Data Bank (BADEHOG).
Note: A household with Internet access is one in which the Internet is generally available to be used by all members of the household at any given time. The connection and devices may or may not be the property of the family, but they must be considered among the household's assets. The household's Internet connection should be operational at the time of the survey.
[a] Children aged 5 to 12 years. The information on Argentina refers only to urban areas. The information on Chile and Ecuador is from 2017.

On average, the number of children in lower-income households in countries in the region is four times greater than the number of children in higher-income households. This makes it difficult for them to access the Internet within the same household as more devices are required for each of them to be connected.

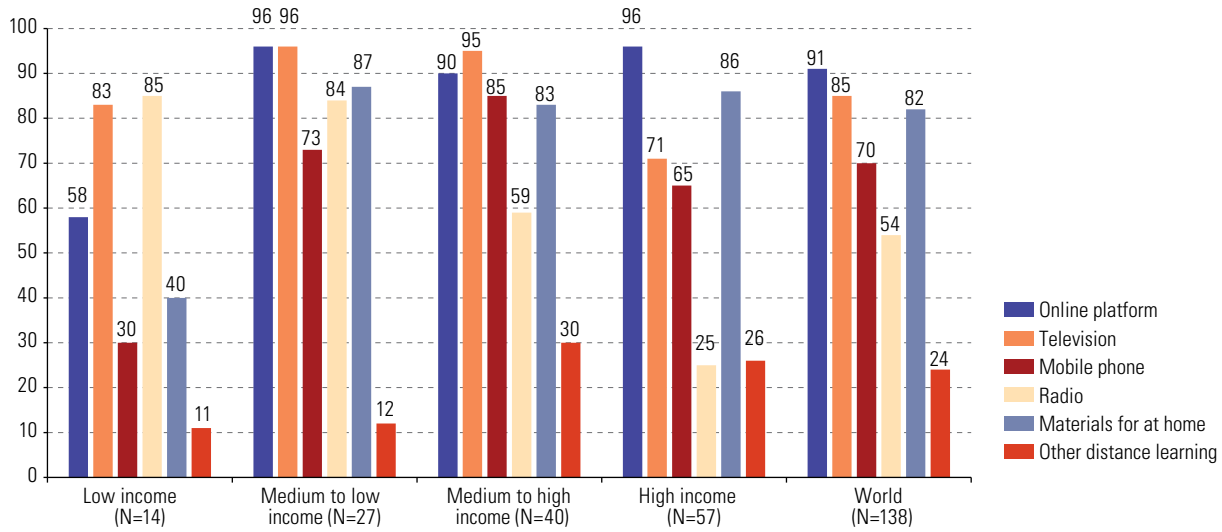
In order to ensure inclusive and equitable education and promote learning opportunities throughout the educational cycle, it is essential to develop the digital skills of educators and ensure the adequacy of educational content in the digital environment.

At the global level, faced with the need to close schools because of COVID-19, countries responded with remote learning solutions, ranging from printed materials to take home to the use of traditional media, such as television and radio, as well as digital platforms. In general, countries opted for a combination of solutions using different technologies. Media such as radio and television have been more popular in low-income countries (92%) than in high-income ones (25%). By contrast, 96% of high-income countries offered distance learning via online platforms for at least one level of education, compared to 58% of low-income countries (see figure III.9) (UNESCO and others, 2021).

The roll-out of inclusive distance learning strategies calls for a comprehensive approach to the pandemic through the design of an exhaustive plan that is consistent with other economic, social and health-related actions, as well as actions related to support for digital inclusion. A total of 70% of countries that responded to the survey from the Institute for Statistics of the United Nations Educational, Scientific and Cultural Organization (UNESCO) (sample of 82 countries) planned to offer free or subsidized Internet access in 2021 in order to ensure connectivity for remote learning, while 60% had considered subsidizing access devices.

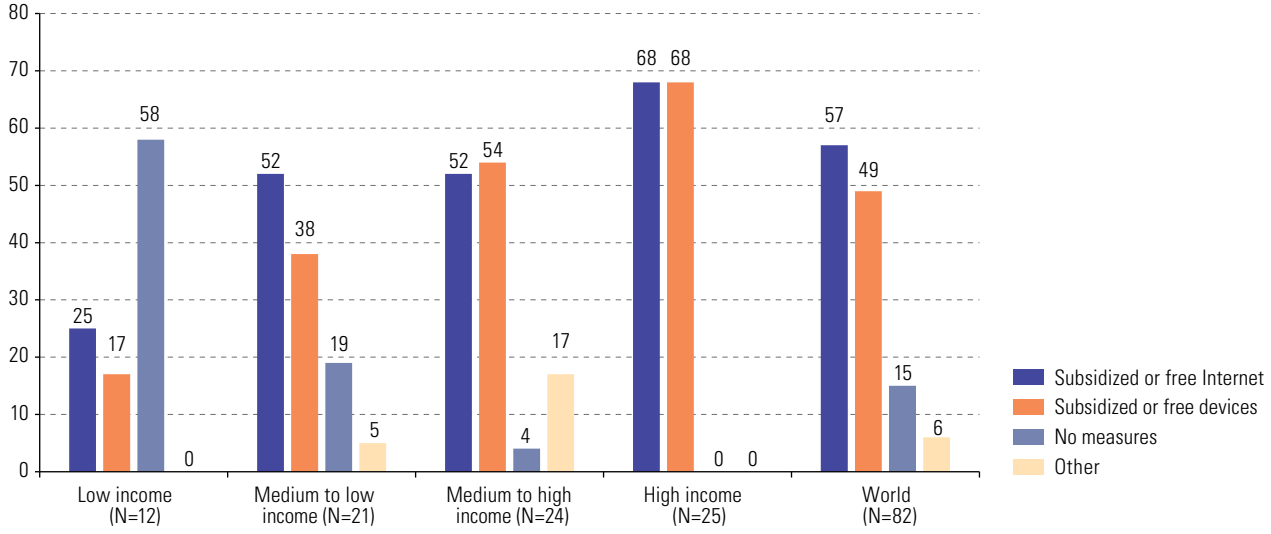
This type of strategy has been implemented to a greater extent in low-income countries, which has serious implications for developmental equality in terms of the digital gap and access to education (see figure III.10).

Figure III.9
Proportion of countries that offer come form of distance learning for at least on level of education, by income level
(Percentage of countries)



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) and others, What's Next? Lessons on Education Recovery: Findings from a Survey of Ministries of Education amid the COVID-19 Pandemic, Paris, Washington D.C., 2021.

Figure III.10
Proportion of countries that established measures to facilitate online remote learning, by income level
(Percentage of countries)



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO) and others, What's Next? Lessons on Education Recovery: Findings from a Survey of Ministries of Education amid the COVID-19 Pandemic, Paris, Washington D.C., 2021.

The responses of Latin American and Caribbean countries to the COVID-19 pandemic in terms of education have been varied and in accordance with international practices. In 17 of 19 countries, there are digital platforms for students, which in 15 cases were complemented by television-based strategies (see table III.2). Only five countries had strategies that took Internet connectivity into account when designing a remote online education plan.

Table III.2
Latin America and the Caribbean: distance learning initiatives during the pandemic, by means of communication

Country	Digital platform for teachers	Digital platform for students	Television programmes	Radio programmes	Online courses	Provision of computers	Internet connection	Workbooks or guides
Argentina	•	•	•	•	•	•	•	•
Bolivia (Plurinational State of)	•	•	•	•	•			•
Brazil	•	•	•		•	•		
Chile	•	•	•		•	•	•	•
Colombia	•	•	•	•	•	•		
Costa Rica	•	•	•	•	•			•
Cuba		•	•					•
Ecuador	•	•	•	•	•			•
El Salvador	•	•	•	•		•	•	•
Guatemala		•	•		•			•
Honduras	•	•	•		•			•
Mexico	•	•	•	•	•			•
Nicaragua			•					•
Panama	•	•			•	•		•
Paraguay	•	•			•	•	•	
Peru	•	•			•	•		
Dominican Republic	•	•			•	•		•
Uruguay	•	•	•		•	•	•	•
Venezuela (Bolivarian Republic of)			•		•			

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Educational, Scientific and Cultural Organization (UNESCO), Information System on Educational Trends in Latin America (SITEAL), "Sistematización de respuestas de los sistemas educativos de América Latina a la crisis de la COVID-19", August 2020 [online] https://www.siteal.iiep.unesco.org/respuestas_educativas_covid_19.

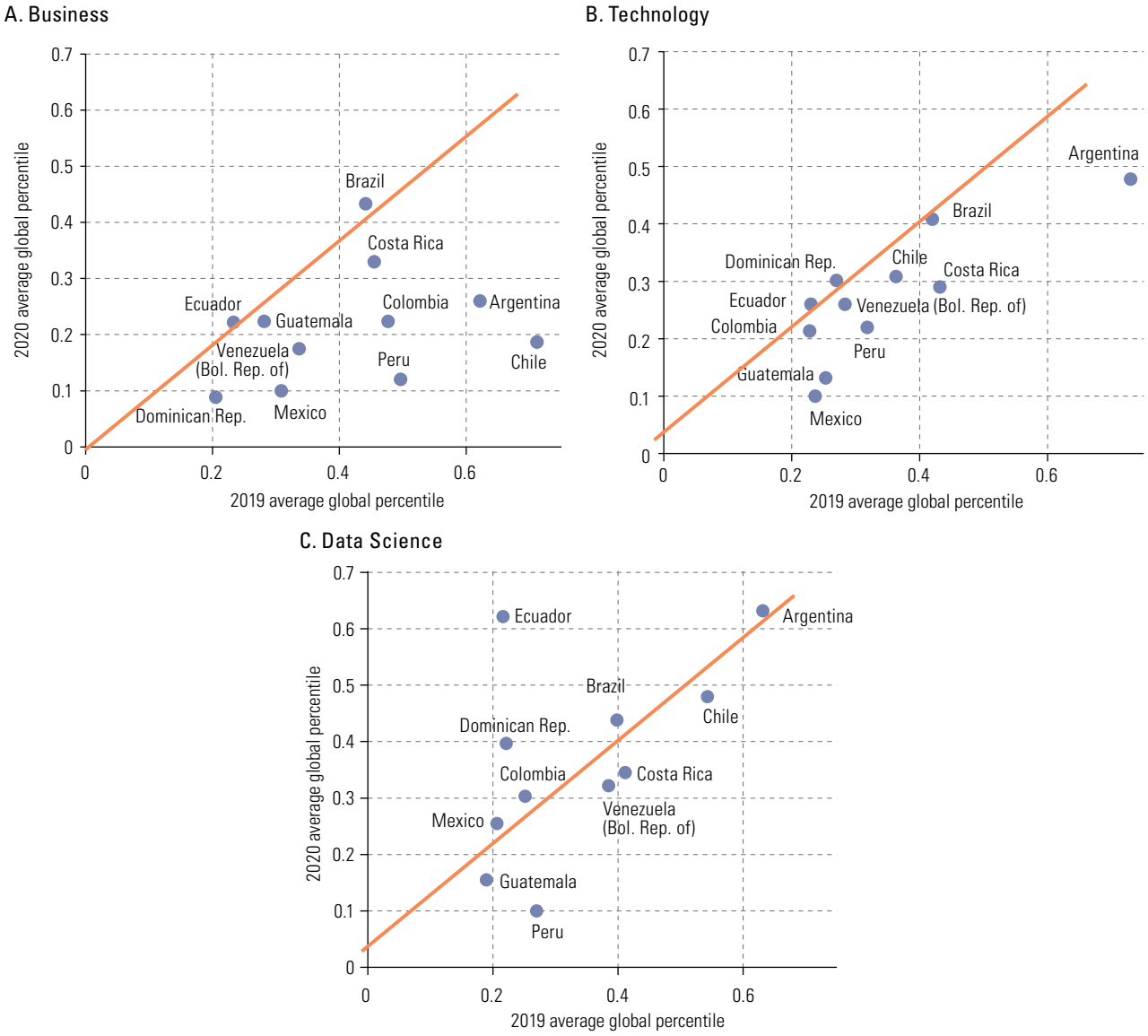
Young people's ease with technology and their natural inclination to use it are facilitating the adoption of solutions such as Massive Open Online Courses (MOOC). These are online courses that can be accessed by anyone who has a computer and an Internet connection. These courses offer students a way of learning in an environment similar to an online class, but they are usually less structured and do not require any tuition fees or any commitment to an academic programme.

When educational establishments closed because of the pandemic, many students chose to take advantage of the opportunities offered by massive online learning. The phenomenon has been the same in different countries in the region and shows the potential of this type of solution to achieving the higher levels of educational development and inclusion in different areas that will be key to the region's productive future.

Thanks to MOOCs, there has been significant progress in data science in Latin America and the Caribbean. A number of countries have gained ground in terms of their international competitiveness in this field by means of online courses, with Brazil, Ecuador and the Dominican Republic standing out. There has been a stagnation in interest in technology-related fields, which includes courses on computer networks, databases, human-computer interaction, operating systems, software engineering and security engineering. However, there are countries that continue to be quite competitive in general, such as Argentina (see figure III.11).

In order to develop the skills that will be required in the future economy, there will need to be significant efforts and innovative training solutions in the public and private spheres. A profound change is rapidly taking place in labour markets, accelerated by the pandemic. In the near future, it is these new skills that will be decisive factors in employment, competitiveness and economic growth.

Figure III.11
Average global percentile in different fields (business, technology and data science)



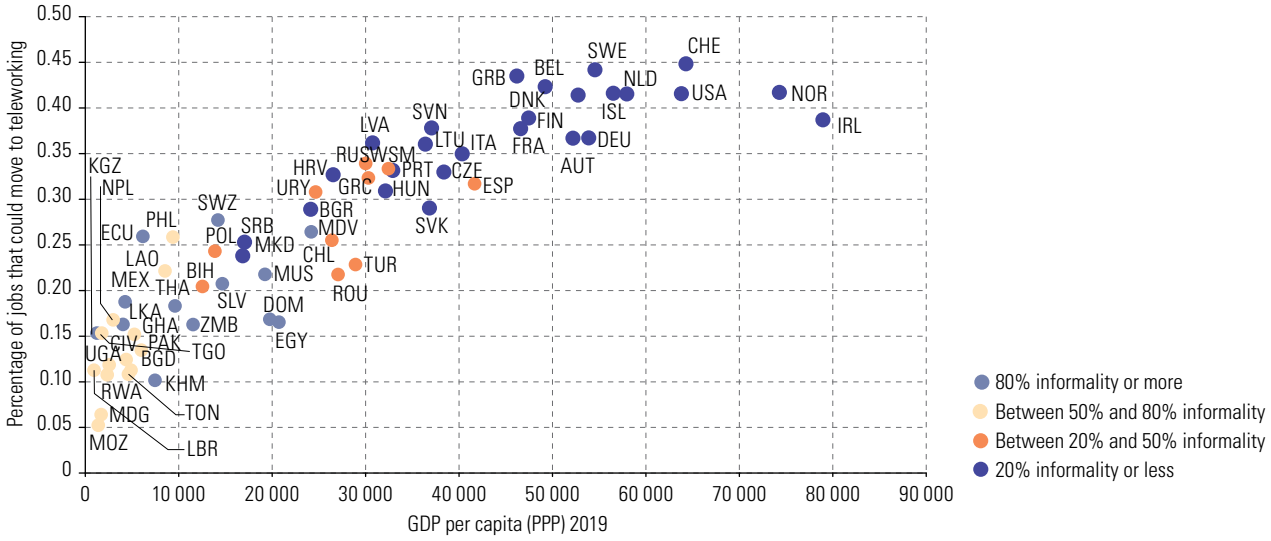
Source: M. Hilbert, "Grandes datos para monitorear los efectos del COVID-19 en la economía digital en América Latina y el Caribe", Regional observatory for digital development, 2021 unpublished.
Note: The countries above the diagonal line on the graphs improved their position in 2020 compared to 2019. Those below the line lost ground at the global level.

2. Rethinking the relationship between work and in-person attendance

Teleworking has been essential to maintaining labour activity and avoiding a greater proliferation of infections. Although 7.9% of people around the world worked from home full-time prior to the pandemic, primarily in traditional crafts or manufacturing, only a fraction of them did so via teleworking (ILO, 2020).

The potential to work remotely varies from one country to another owing to structural factors, such as the features of individual labour markets, the production sector, levels of informality and quality of digital infrastructure. In fact, the percentage of positions that could move to teleworking is positively linked to the level of GDP per capita and lower levels of informality (see figure III.12).

Figure III.12
Probability of teleworking, GDP per capita and level of informality, 2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Household Survey Data Bank (BADEHOG); J. Dingel and B. Neiman, "How many jobs can be done at home?", NBER Working Paper, No. 26948, Cambridge, National Bureau of Economic Research (NBER), 2020, and data from the International Labour Organisation (ILO).

In Europe and the United States, almost 40% of workers may work from home. In Latin America, meanwhile, it is estimated that around 21% of employees are able to work remotely (ECLAC, 2020). This difference is because, at the sectoral level, the probability of teleworking is over 80% in professional, scientific and technical services and in education, finance and insurance. In Latin American and Caribbean countries, around a fifth of employees in these sectors already work from home. For their part, employees in wholesale and retail trade, and agriculture, the greatest sources of employment in the region, have teleworking probabilities of 15% and 1% respectively. Other factors affecting the low likelihood of teleworking in Latin American and Caribbean countries are digital infrastructure, the level of digitalization of enterprises and digital skills.

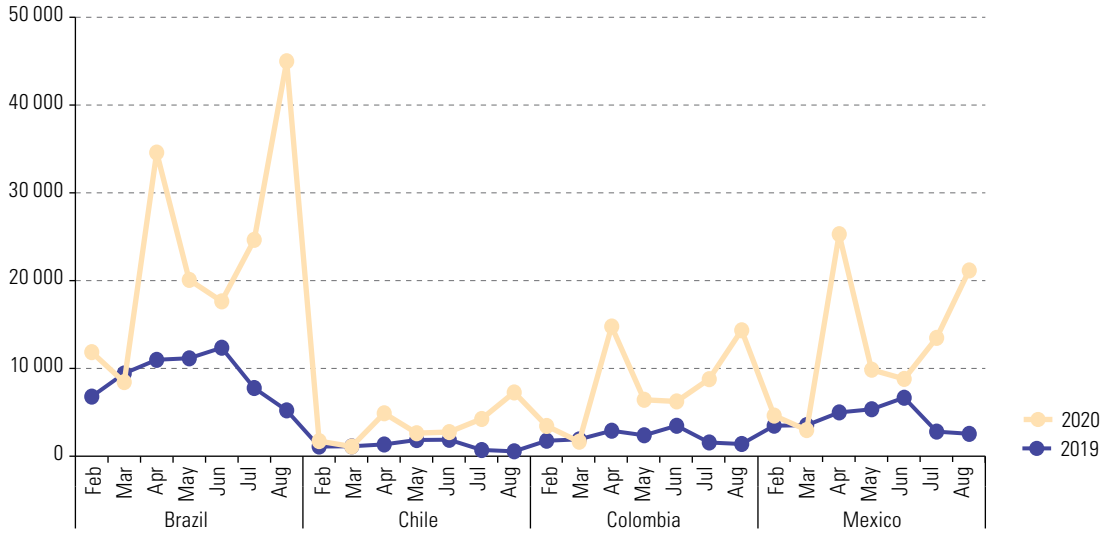
3. The e-commerce boom

During the pandemic, enterprises have translated their in-person activities to an online format in view of the need to maintain their sales and marketing activities. Comparing the period from February to August 2019 with the same period in 2020, there is a clear increase in new business websites. Between February and August 2020, the annual monthly growth in the number of new business websites was close to 60% in Brazil and Chile, and 128% in Colombia and Mexico. These values are significantly higher than those for the same period the previous year, when they were, respectively, -2% and 2% (see figure III.13).

The online commercialization of goods and services also changed how websites operate, moving from a passive presence to a transactional one. Analysis of business websites showed that, between January and June 2020, in Brazil, Chile, Colombia and Mexico, 20% of the changes made to existing websites corresponded to this transition to transactional sites.

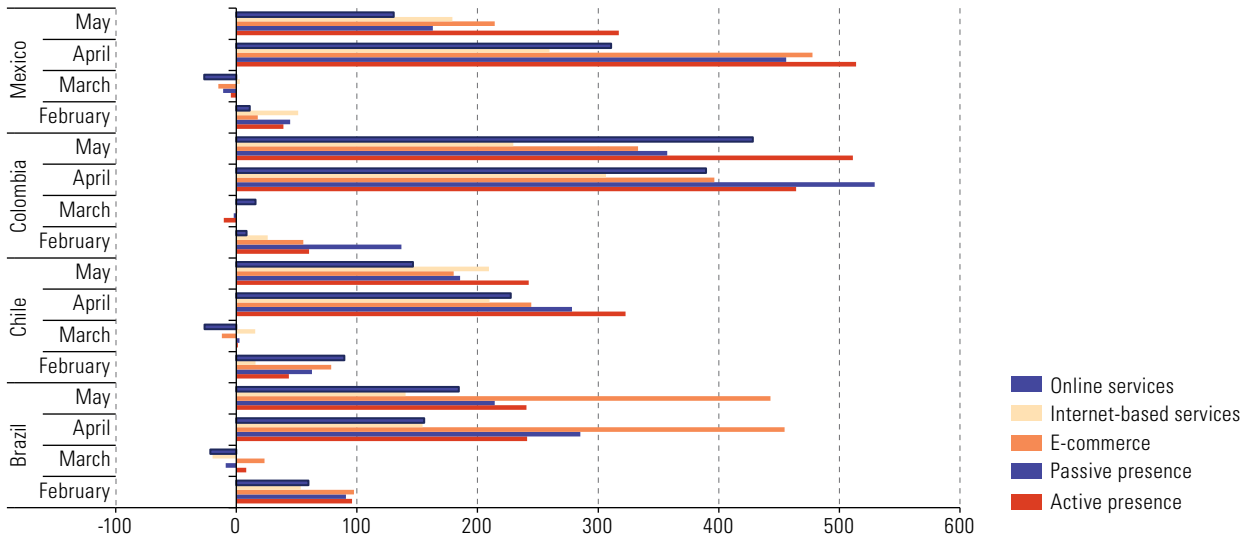
The biggest increases in online presence were among transactional (active presence) business sites and e-commerce platforms. In Brazil and Mexico, the number of new e-commerce grew by more than 450% in April 2020 in comparison with the same month in 2019. Moreover, the number of sites with an active presence in Colombia and Mexico increased by approximately 500% in the same period (see figure III.14).

Figure III.13
Latin America (4 countries): new business websites by month
(Number of websites)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), "Midiendo la economía de Internet en América Latina: un análisis de Big Data para Colombia, México, Brasil y Chile", project "Big data for measuring the digital economy in Latin America and the Caribbean", unpublished.

Figure III.14
Latin America (4 countries): year-on-year growth in business websites by type in selected countries, 2019-2020
(Percentages)

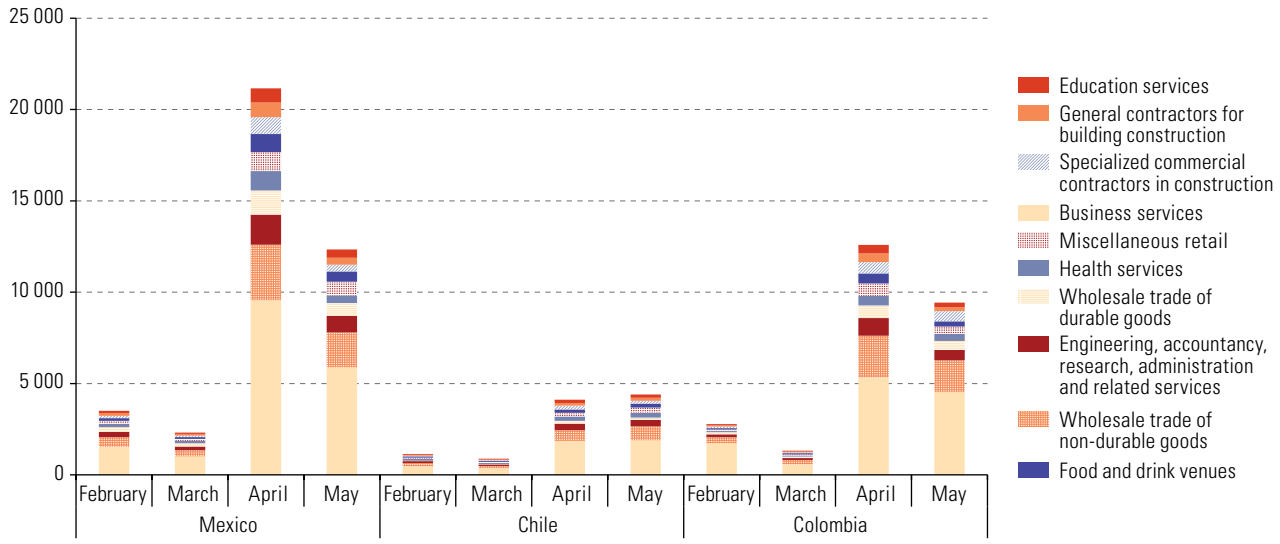


Source: Economic Commission for Latin America and the Caribbean (ECLAC), project "Big data for measuring the digital economy in Latin America and the Caribbean", on the basis of Dataprovider.com, 2020.

Note: Categories are defined by how enterprises generate income through Internet use (Oostrom and others, 2016). Passive online presence: websites that only provide information or advertising on its commercial activities. Active online presence: websites that allow interaction with clients, such as providing support for their main commercial activities (for example, online sales, customer service). E-commerce: online shops with no physical presence whose income depends on Internet sales. Online services: provision of online services that exist independent of the Internet (for example, hospitality, tourism). Internet-based services: businesses that make Internet operations possible (web design, hosting services, cloud services and application development).

Having an online presence is vital for various sectors. Analysis of the growth of business websites by sector confirms the importance of online channels for retail trade, construction contractors and services in business, health and education, which increased by more than 200% during the first months of the pandemic (see figure III.15).

Figure III.15
Chile, Colombia and Mexico: new business websites by sector of activity by month, 2020
(Number of websites)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), project "Big data for measuring the digital economy in Latin America and the Caribbean", on the basis of Dataprovider.com, 2020.

Digital transformation processes, in which enterprises significantly improve their websites and develop logistics and shipping procedures, are practicable for medium-sized enterprises. Micro, small and medium-sized enterprises (MSMEs) have looked for more attainable solutions, such as joining large online market platforms and having a social media presence, in order to guide their customers to their online sales channels.

The presence of new sellers on e-commerce platforms has increased enormously. Data collected by MercadoLibre.com during the pandemic showed a large increase in the number of new registered sellers. In the countries where this online market is most developed, the number of new sellers grew fourfold, while it increased sixfold in countries where the platform is least developed (see figure III.16).

Figure III.16
Latin America (18 countries): number of new sellers on MercadoLibre.com, 2019–2020

A. In countries with the most online market development

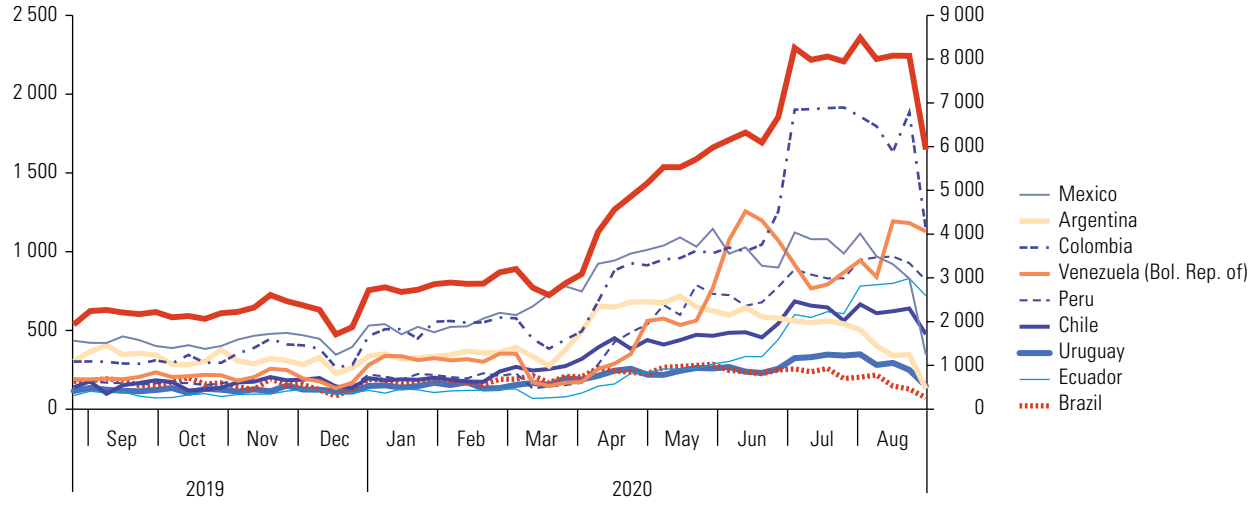
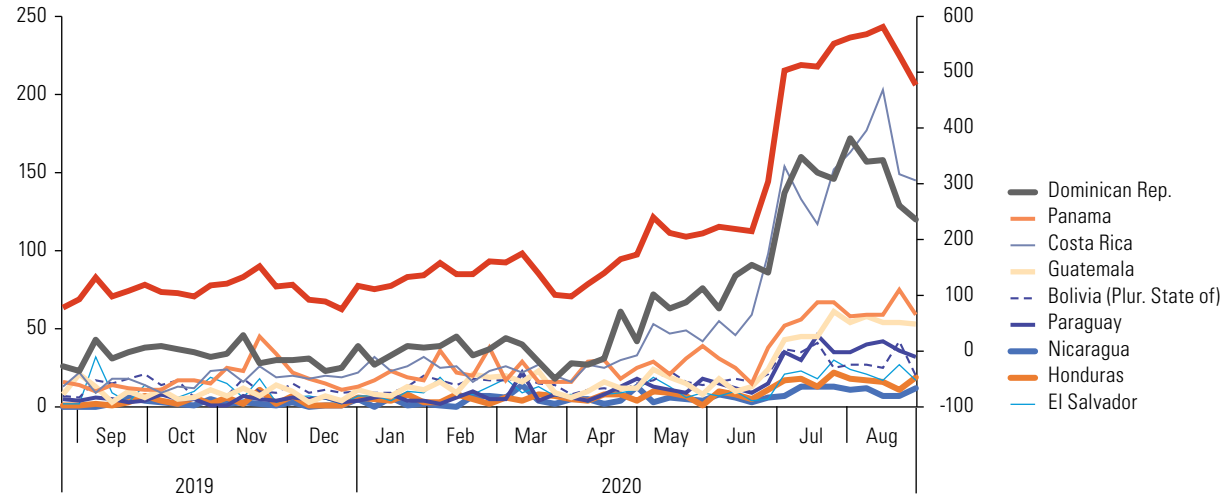


Figure III.16 (concluded)

B. In countries with the least online market development



Source: M. Hilbert, "Grandes datos para monitorear los efectos del COVID-19 en la economía digital en América Latina y el Caribe", Regional observatory for digital development, 2021 unpublished.

As shown, the acceleration of digitalization has occurred primarily in links in the production chain relating to sales, commercialization and supplier relationships. The same has not been true for the incorporation of digital technologies into the production process itself, which has the greatest potential in terms of productivity and sustainability.

4. Digitalization of industry

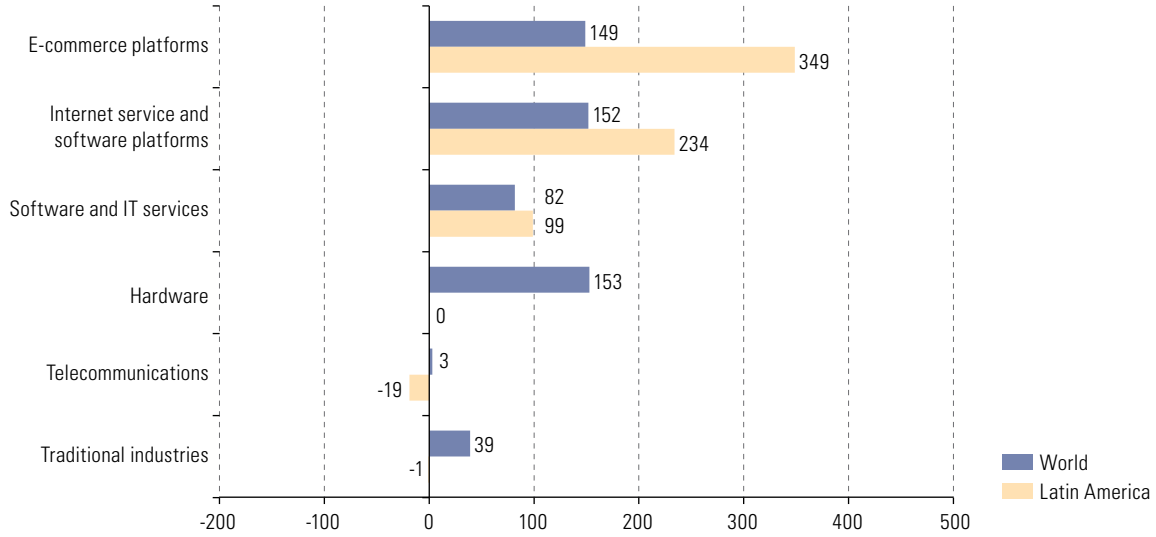
In under 20 years, the expansion of digitally-enabled online business models to market goods and services has strengthened the digital economy and boosted its importance to traditional industry. New data-intensive business models have expanded rapidly. At present, large digital platforms have become the most valuable enterprises in terms of their global market capitalization. In March 2021, 9 of the 10 enterprises with the world's greatest market value were types of digital platform (e-commerce, software or social network) or were IT-related.

The economic crisis caused by COVID-19 has had a serious impact on many industries, but not on the digital industry.[2] This industry has expanded even further during the last year and, as of March 2021, accounted for 28% of the value of the world economy (by market value of companies) and 12% of the regional economy. E-commerce, Internet service and software platforms were the segments that grew most in terms of their stock-market value between March 2019 and March 2020. At the global level, they grew between 149% and 152%, respectively, while their growth within the region was 349% and 243% (see figure III.17).

Digital platforms make significant contributions to the economy by promoting innovation, facilitating links between supply and demand in goods and services, contributing to making the use of assets more efficient, and opening up opportunities to do business and improve productivity for firms, including MSMEs. However, they also present challenges in terms of competition owing to market and user data concentration, as well as labour disputes. The flexibility offered by labour relations created by some types of digital platforms (in the manner of the gig economy) is associated with difficulties in guaranteeing social protection for workers, their trade union rights and the formalization of employment relationships.

[2] Digital industry refers to the set of sectors whose core business is related to information technologies. This includes the telecommunications, hardware and software sectors, as well as digital technology-based platforms supplying goods and services.

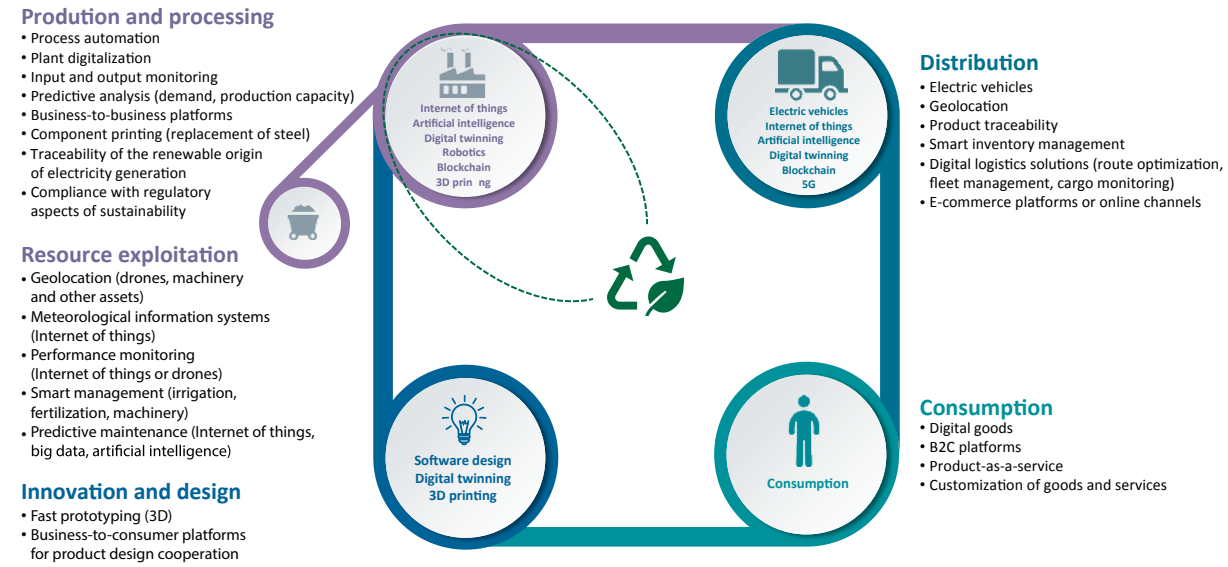
Figure III.17
Change in value of the digital technology industry in comparison with traditional sectors, by industrial segment, March 2019 and March 2021
(Percentages)



Source: Regional observatory for digital development, on the basis of Bloomberg data for the 5,000 companies with the highest market capitalization.

The disruptive changes driven by digital technologies are permeating traditional industries and transforming operational and production models. The development of 5G makes it possible to create smart factories and make use of technologies, such as automation and robotics, AI, augmented reality and the Internet of things, at different stages of the value chain (see diagram III.2). Real-time access to information for making decisions throughout the value chain is a crucial competitive advantage in making efficient use of resources and taking better care of demand. Solutions based on cloud computing enable better integration of the various stages in the production chain. They also make it possible to optimize processes and lower costs, as well as reducing delivery times, improving logistics management and capturing consumer attention.

Diagram III.2
Digital transformation of the production chain

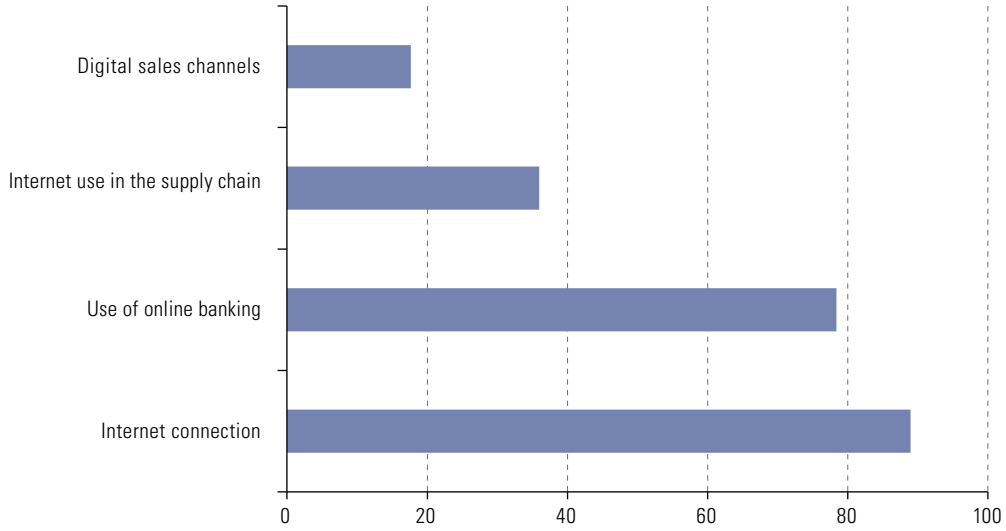


Source: Economic Commission for Latin America and the Caribbean (ECLAC), Digital technologies for a new future (LC/TS.2021/43), Santiago, 2021.

Smart production systems can increase competitiveness with a lower environmental footprint to the extent that enterprises use digital tools to map and reduce that footprint. This helps them to assess their impact on climate change and modify their production processes.

Within Latin America and the Caribbean, the digitalization of production processes is lagging behind the rate in other regions. In general, enterprises have a high level of connectivity (above 90%) and around 80% use online banking. However, few of them incorporate digital technologies into their production processes. For example, only 37% of enterprises use the Internet in their supply chain, in contrast to the 70% of companies in OECD countries (see figure III.18).

Figure III.18
Latin America and the Caribbean: digitalization of production processes, 2018
(Percentage of enterprises)



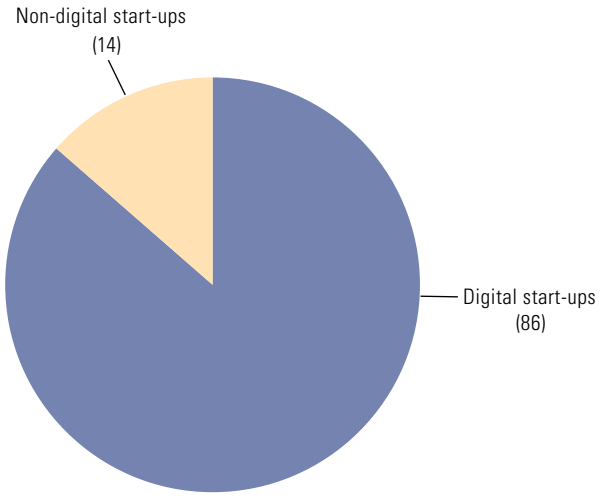
Source: Regional observatory for digital development, on the basis of data from surveys on information and communications technology in enterprises in Chile, Colombia and Brazil.

The level of adoption of new technologies varies from one industry to another. The agricultural and automotive sectors have been incorporating digital technologies into their production chains for some time. This has improved their productivity and sustainability, as well as making a positive impact on their production ecosystems by boosting innovation. In the agricultural sector, efficiency has improved dramatically thanks to the adoption of various digital technologies, such as sensors for precision farming, smart georeferencing using satellite systems and drones to monitor crops, and the use of software through applications of websites to make predictions relating to crops and climate change (ECLAC, 2021a).

Start-ups based on digital technologies are a key driver of digital development. Over the last 10 years, they have received a major boost at the regional level, to the extent that, for every 10 start-ups, almost nine are based around digital technologies or belong to the sector (86%). Such innovation is happening most in South America, which accounts for 82% of the total number of start-ups. Brazil and Mexico stand out, and provide, respectively, 57% and 13% of the total number of digital start-ups in Latin America and the Caribbean (see figure III.19).

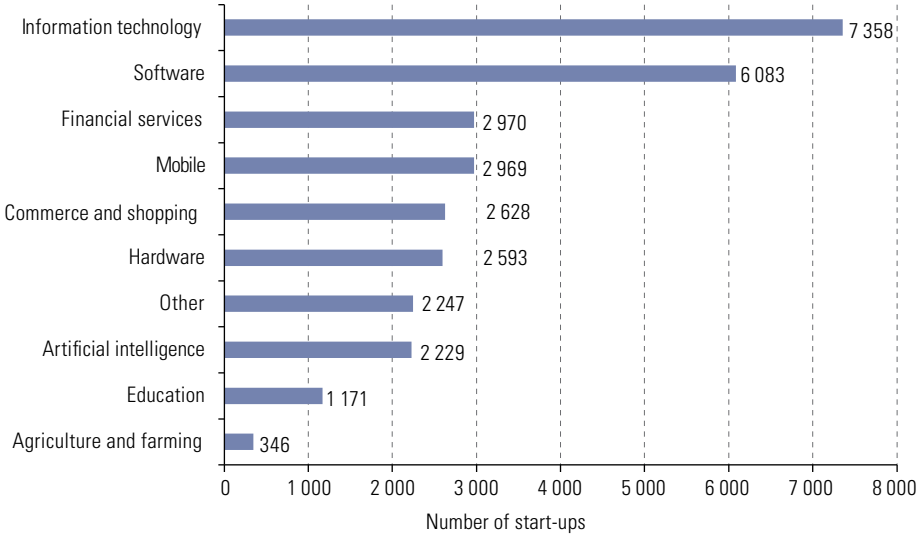
Digital start-ups are largely concentrated in the IT segment, with 24% of the total number of enterprises, followed by the software industry, with 20% of digital start-ups. Notable features include the rise of innovations related to AI solutions, with 7% of the region's total digital start-ups, and developments related to financial service technologies and the education sector, the latter as a direct result of the pandemic (see figure III.20).

Figure III.19
Latin America and the Caribbean: number of digital and non-digital start-ups appearing between 2011 and 2021
(Percentages)



Source: Regional observatory for digital development, on the basis of data from Crunchbase.com.
Note: The year 2021 includes data up to November of that year.

Figure III.20
Latin America and the Caribbean: number of digital start-ups, by industrial segment, established between 2011 and September 2021

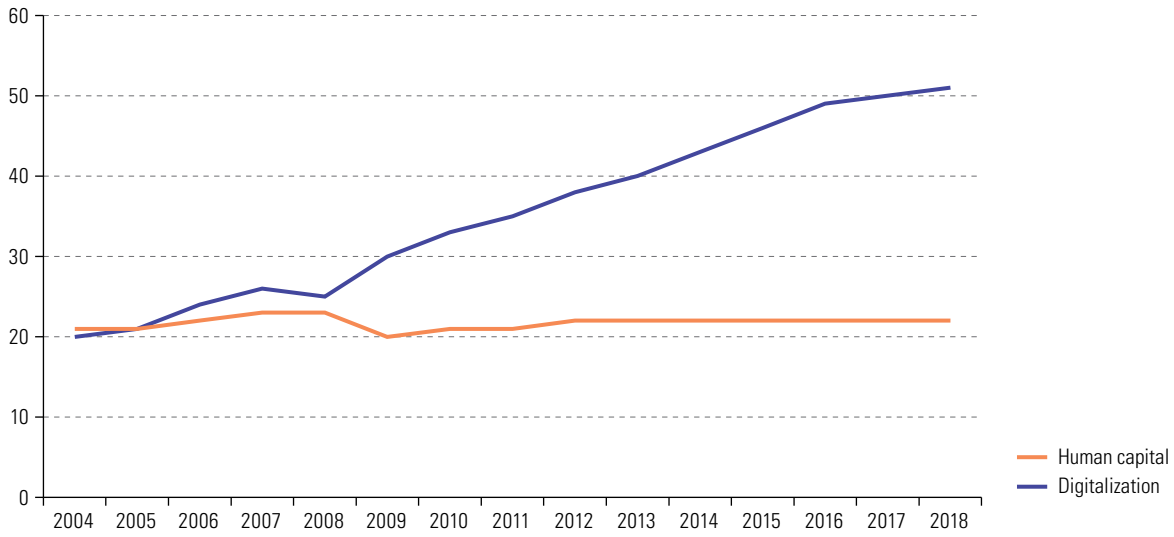


Source: Regional observatory for digital development, on the basis of data from Crunchbase.com.
Note: The categories are not mutually exclusive.

5. Digital skills and future employment

A lack of digital skills limits labour market participation in the digital economy. Between 2004 and 2018, the digitalization index of countries in the region has more than doubled while the human capital index has been stagnating (see figure III.21).

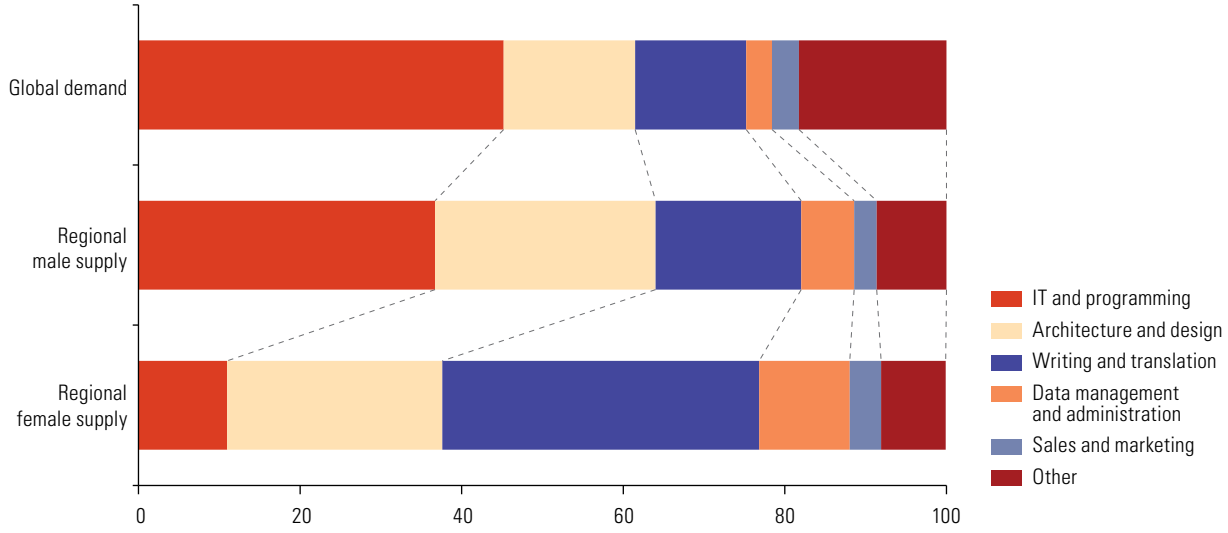
Figure III.21
Latin America: digitalization index and human capital index, 2004–2018
(Index on a basis of 100)



Source: Regional Broadband Observatory (ORBA), on the basis of Telecom Advisory Services.

A lack of digital skills particularly limits the participation of women in the digital economy. The supply of workers with digital skills in Latin America and the Caribbean is less than global demand. The male workforce that has these skills is three times larger than the equivalent female workforce. These facts highlight the need for specific incentives and policy instruments to achieve greater coordination between supply and demand in the workforce, as well to further incorporate women into the digital labour market (see figure III.22).

Figure III.22
Latin America: asymmetry between supply and demand in digital skills between countries in the region
(Percentage of jobs)

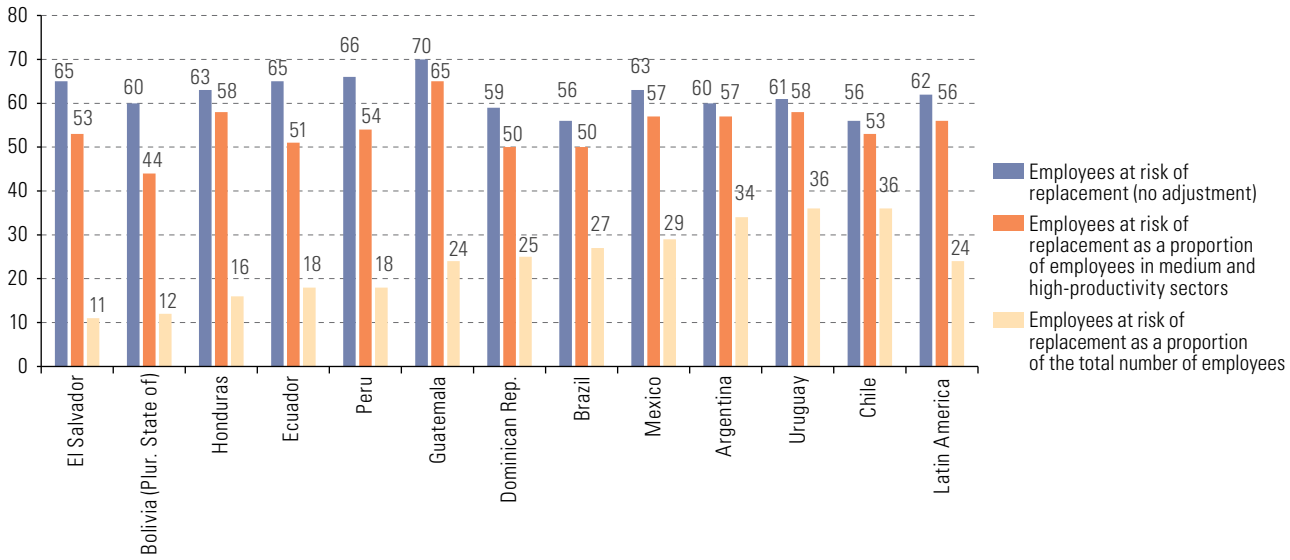


Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Tracking the digital footprint in Latin America and the Caribbean: Lessons learned from using big data to assess the digital economy* (LC/TS.2020/12/Rev.1), Santiago.
Note: Based on data from Freelancer.com.

The process of digitalizing the economy is transforming production and business models, with profound effects on the world of work. The cross-cutting nature of implementing new technologies will cause many existing jobs to disappear. An even larger number of jobs will be changed and other new ones will be created. The technological feasibility of computerizing tasks associated with specific jobs is taken into account in estimates on the risk of job loss as a result of increased automation through AI and robotics solutions. The more a job involves tasks that could be automated, the more likely it is that it will be replaced.

At the regional level, 24% of jobs may be at risk of being replaced and 16% of them at high risk of being replaced (Weller, Gontero and Campbell, 2019). However, there is a large sector of the economy with subsistence needs, associated with a low-productivity labour supply, far from the technological cutting-edge and unlikely to be affected by processes of substitution or production sector complementarity, as occurs with jobs in medium- or high-productivity sectors. Jobs at zero risk of being replaced are those that tend to be of low quality, in terms of income and labour and social rights. The regional estimate made using Frey and Osborne's original method (2017) indicates that, on average, 62% of jobs are at risk of computerization. A total of 43% of jobs are at a high risk of replacement (see figure III.23).

Figure III.23
Latin America (12 countries): jobs susceptible to replacement, Frey and Osborne, original and adjusted version
(Percentages)



Source: C. Frey and M. Osborne, "The future of employment: how susceptible are jobs to computerisation?", Technological Forecasting and Social Change, vol. 114, 2017.

Amid the loss of existing jobs and the creation of new job opportunities is the risk of inequalities and divisions. Different groups of employees, in line with their gender and level of education, are affected unequally by the risks of technological substitution. Some of these processes bring risks of increased polarization and segmentation of the labour market, challenges that must be addressed through coordinated public policies.

C. Strategic action lines for an inclusive digital transformation

In the context of the pandemic, policies intended to promote and organize digital activities have acquired a renewed urgency and relevance. The possibilities for charting new development paths and moving towards a transformative recovery will depend on what happens in the digital environment and how digital transformation is incorporated into the economy and society.

The intense and accelerated digitalization process creates tensions at different levels of normative and regulatory frameworks. Governance of digital development requires updating legal frameworks in areas as varied as telecommunications, competition, employment, taxation and trade, as well as establishing new regulations and institutional structures in areas such as cybersecurity, protection of personal data, data flows, ethics and AI. It is also necessary to prioritize public policies that foster an innovation ecosystem suited to the complexities, benefits and challenges of technological platforms.

In view of the multifaceted and cross-cutting nature of digital technologies, various levels of government have responsibilities related to the digital transformation and its economic and social effects. Managing this complex network of policy areas requires a comprehensive view of digital policy at the national level and its articulation between different actors and levels of government.

Moreover, the cross-border dimension of the digital economy, as well as the associated actors and flows, imposes the need to follow international developments and guidelines in various areas, while taking into account the reality and national perspective. For this reason, regional coordination on various normative and regulatory aspects, concerning trade, taxation, data flows, data protection and cybersecurity, also acquire urgency and relevance.

It is impossible to imagine a post-pandemic world without the digital transformation. Digital governance must be aimed at building a welfare state, underpinned by a competitive and sustainable production model based on new technologies. This involves:

- Promoting equality and inclusion, ensuring adequate access to digital technologies, reducing socioeconomic barriers that restrict their use, developing the skills needed to use them and adopt them in economic and social activities, and promoting the supply of digital solutions for the provision of public services, such as education and health care.
- Protecting economic, social and labour rights of the population, promoting the provision of public services and government via digital channels, as well as the creation and digital skills and capabilities among the population.
- Increasing confidence in the use of digital solutions through the protection of personal data, the prevention of cybercrimes and the protection of digital users and consumers.
- Promoting a structural change through innovation and the dissemination of technology in production facilities, the creation of new business models, insertion in global value chains and the implementation of financing mechanisms that promote the digital transformation.

Digital development policies must therefore be organized around five action lines that focus on: (i) building an inclusive digital society; (ii) fostering a digital transformation in the production sector; (iii) increasing digital trust and security; (iv) promoting competitive digital markets and (v) strengthening regional digital cooperation.

1. Building an inclusive digital society

- Access to high-speed broadband for effective participation in the digital era. This requires funding to be found. In this case, options may be to consider reforming the Funds for Universal Access and Service and implementing a regulatory "sandbox" that enables operators to directly manage some of their contributions to funds to cover the costs of providing services to lower-income households.[3] This also involves allocating revenue to participants in the information and communication technology sector, as well as attracting investment in order to expand fixed broadband coverage and improve mobile broadband connection speeds.
- Universalization of broadband connectivity with the creation of a basic digital package that enables lower-income sections of the population to enjoy effective connectivity and take advantage of the

[3] Authorization for self-management of resources may be subject to the fulfilment of conditions set by regulators to promote competition between service providers, which will lead to improved conditions being offered so that this authorization can be obtained.

benefits of digital technologies. This package would include a fixed or mobile broadband plan, one or more access devices (smartphone, tablet and laptop) and a plan for strengthening digital skills. In this context, coordination between the public and private sectors is essential.

- Review of tax-related issues to facilitate access to services and devices, while strengthening public-private partnerships with suppliers and producers to obtain more favourable conditions in the provision of services and the supply of equipment.
- Access to and creation of digital solutions relevant to the population. This involves measures for regulatory flexibility, for example, in terms of net neutrality, measures that encourage the use of online education, health and government services through a zero-tariff approach that allows users to access such services for free. In addition, the development of mobile applications to access these services should be considered.
- Development and implementation of policies and instruments that include socioeconomic, geographic, age-related and gender-related criteria.

2. Fostering a digital transformation in the production sector

- Support the incorporation of cutting-edge digital technologies into production processes (supply chains, processing, manufacturing and operations), as well as in distribution channels. This involves steps ranging from the adoption of actions to raise awareness of the potential of different technological solutions, to the creation of digital capacities, via, for example, the creation of digital trading platforms.
- Accelerate the roll-out of 5G mobile communication networks that facilitate the use of cutting-edge solutions in the productive sphere. This requires progress in the processes of spectrum allocation and tendering to provide commercial 5G services, as well as updating regulatory frameworks in the telecommunications sector.
- Promote digital entrepreneurship through the development of financing mechanisms that facilitate the creation of technology-based start-ups.
- Promote vocational training and training systems in areas related to digital technologies, with the aim of encouraging the development of digital ecosystems and improving employability.
- Develop and implement specific policies suited to the features of the productive area, the characteristics of the technologies to be disseminated and the specificities of the related industries and enterprises, in terms of production capacities, management and linkages with the local area.
- Encourage public sector innovation. Public administration systems must also transform their service delivery processes. The potential of digital technologies to improve efficiency and effectiveness will be harnessed when all actors in the ecosystem adopt such solutions. Digital innovation in processes linking governments and companies is also essential to creating synergies that encourage the adoption of these technologies.

3. Promoting digital trust and security

- Formulate national cybersecurity strategies that help public and private actors to address cyberattacks in a coordinated manner.
- Strengthen institutionality and regulatory frameworks in the context of data privacy and cybersecurity. It is urgent for regulatory and institutional data protection frameworks to be updated, as well as for the institutional capacities needed to implement them to be created. Cybersecurity regulations should also be aimed at protecting essential infrastructure, where threats can endanger the provision of public services (including water, electricity, telecommunications, transport, the logistics chain and port systems).

4. Promoting fair and competitive digital markets

- Ensure that data are not used or kept in an anti-competitive manner in order to enable equitable access for all actors.
- Develop strategies and policies that include the promotion of competition and data protection to guarantee market access without threats to the security of those involved. In the context of digitalization, defining data ownership is essential to regulation. It is therefore necessary to amend anti-monopoly policies to include privacy regulations.
- Facilitate access to data (for example, through a market that can only be accessed by paying a fee) and ensure an adequate level of protection for information in order to improve the competitive position of MSMEs in the digital economy.

5. Strengthening regional digital cooperation

- Create conditions for strengthening regional digital cooperation. At present, the region does not have an institutional framework for discussing policies, norms and standards.
- Promote greater coordination within the region and subregional blocs to identify thematic priority areas and their operational management. Notable here is the Ministerial Conference on the Information Society in Latin America and the Caribbean, which provides a space to define shared principles and priorities by bringing together 33 countries in the region and representatives from the private sector, civil society and the technical community.[4]
- Launch a regional digital market that makes it possible to establish a collective strategy to increase trade, expand the digital economy and increase competition through regulatory consistency, the integration of infrastructure and the development of digital platforms, cross-border data flows and measures to facilitate trade. In this context, there could be further regulatory harmonization in relevant trading blocs, such as the Pacific Alliance, the Mesoamerica Project and the Southern Common Market (MERCOSUR).

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[4] Among other agreements reached under the framework of the Digital Agenda for Latin America and the Caribbean (eLAC2022), it is worth mentioning those relating to promoting the development of digital infrastructure and ensuring universal connectivity, encouraging the development of digital skills, promoting inclusion in policy design, coordinating actions aimed at ensuring privacy and the protection of personal data, and encouraging the use of digital technologies for economic recovery (with particular reference to MSMEs), as well as promoting the creation of a regional digital market.

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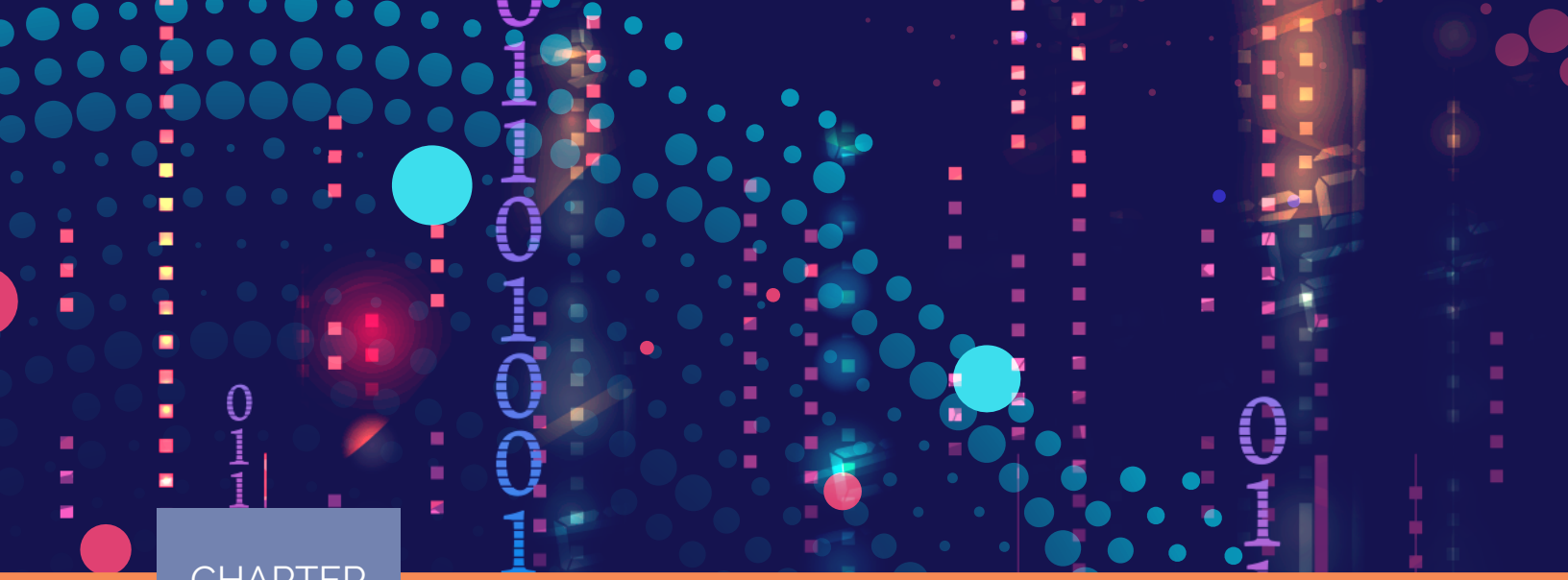


CHAPTER

IV

Harnessing technology and innovation for more sustainable production

A. The need to move towards more sustainable consumption

The 2030 Agenda for Sustainable Development and the Sustainable Development Goals illustrate the urgency of moving towards new models for growth and development, with more sustainable and inclusive consumption and production patterns, for economic, social and environmental matters. This last point, in particular, involves promoting an environmentally friendly economy that is based on the use of renewable energies and "clean" fuels, and where transportation infrastructure and buildings, as well as production, construction and distribution methods, use energy, water and resources efficiently to limit waste production and emissions, reduce consumption and encourage reuse, recycling and recovery.

Sustainable consumption and production seek to promote the use of services and products that meet the basic needs of the population and their quality of life, while reducing the use of natural resources and toxic materials, as well as the production of waste and polluting substances during the life cycle of the service or product, with the aim of ensuring the needs of future generations can be met. The development of science, technology and innovation play an essential role in that regard (CEADU, 2016). These initiatives not only lessen the environmental impact of production processes, but also give rise to new economic opportunities that have positive impacts on the employment and income of the population.

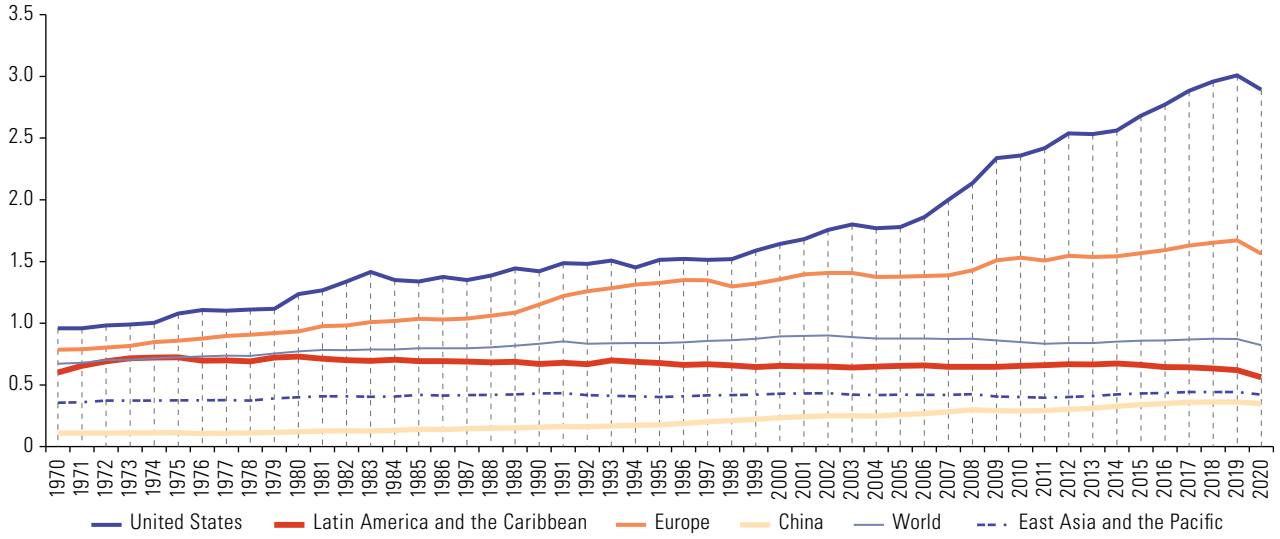
Latin America and the Caribbean faces ever more serious environmental issues, primarily concerning the degradation of forests, land and water, extreme weather events and air pollution. Moreover, the growing public demand for goods and services is continuously increasing environmental pressures. It is therefore clear that the only way for expectations for growth and quality of life to be met sustainably will be if there is a structural and technological change that allows greater economic dynamism alongside increased productivity and environmental efficiency (ECLAC, 2018).

The global economy is dependent on the extraction and consumption of raw materials. Because of this, one of the basic aims of harmonizing economic activity and environmental protection is to reduce the need for natural resources in order to improve productive performance and growth. An examination of trends in the material footprints of different regions reveals considerable differences. For example, analysing the relationship between economic production and domestic material consumption in Latin America and the Caribbean shows that there has been a linear trend in recent decades. While the region has greater material productivity than China and Asia and the Pacific, there are significant gaps when compared to North America and Europe (see figure IV.1).

Domestic material consumption continues to grow in absolute terms globally.[1] However, some progress has been made in decoupling the extraction and consumption of these materials from economic growth, especially in developed countries (see figure IV.2). There are two main reasons for the differences in material productivity. The first concerns technological improvement and increased efficiency in the use of resources, while the second concerns the transition from an extractive production structure that makes intensive use of natural resources to a service-based economy with low material consumption (UNEP, 2021). In essence, environmental efficiency is linked to structural change and the need to develop new sectors, with the broad-scale inclusion of technological innovations and developments that enable the productivity of resources to increase dramatically (ECLAC, 2020).

[1] Includes biomass, metallic and non-metallic minerals, raw materials and processed materials.

Figure IV.1
Global and regional material productivity: domestic material consumption, 1970–2020
(Dollars generated per kilogram of domestic material consumed)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Environment Programme (UNEP), Global Material Flows Database [online] https://www.resourcepanel.org/global-material-flows-database.
Note: The information for 2018 and 2020 is an estimate.

Figure IV.2
Latin America and the Caribbean, Europe and the United States: trends in domestic material consumption and GDP, 1970–2020
(Index: 1970=100)

A. Latin America and the Caribbean

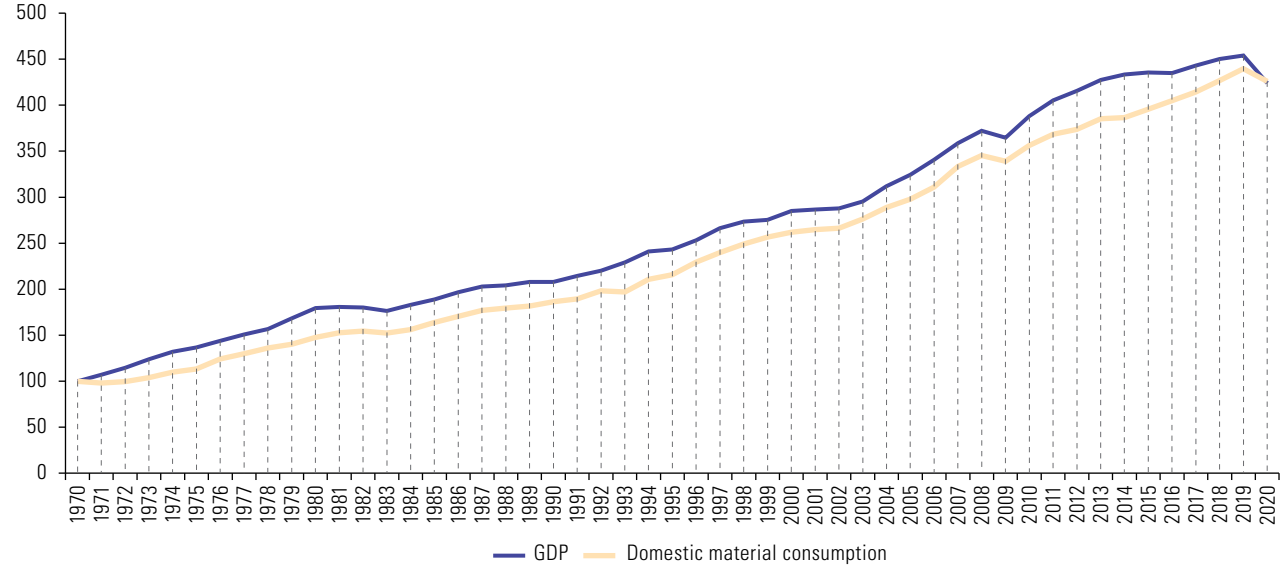
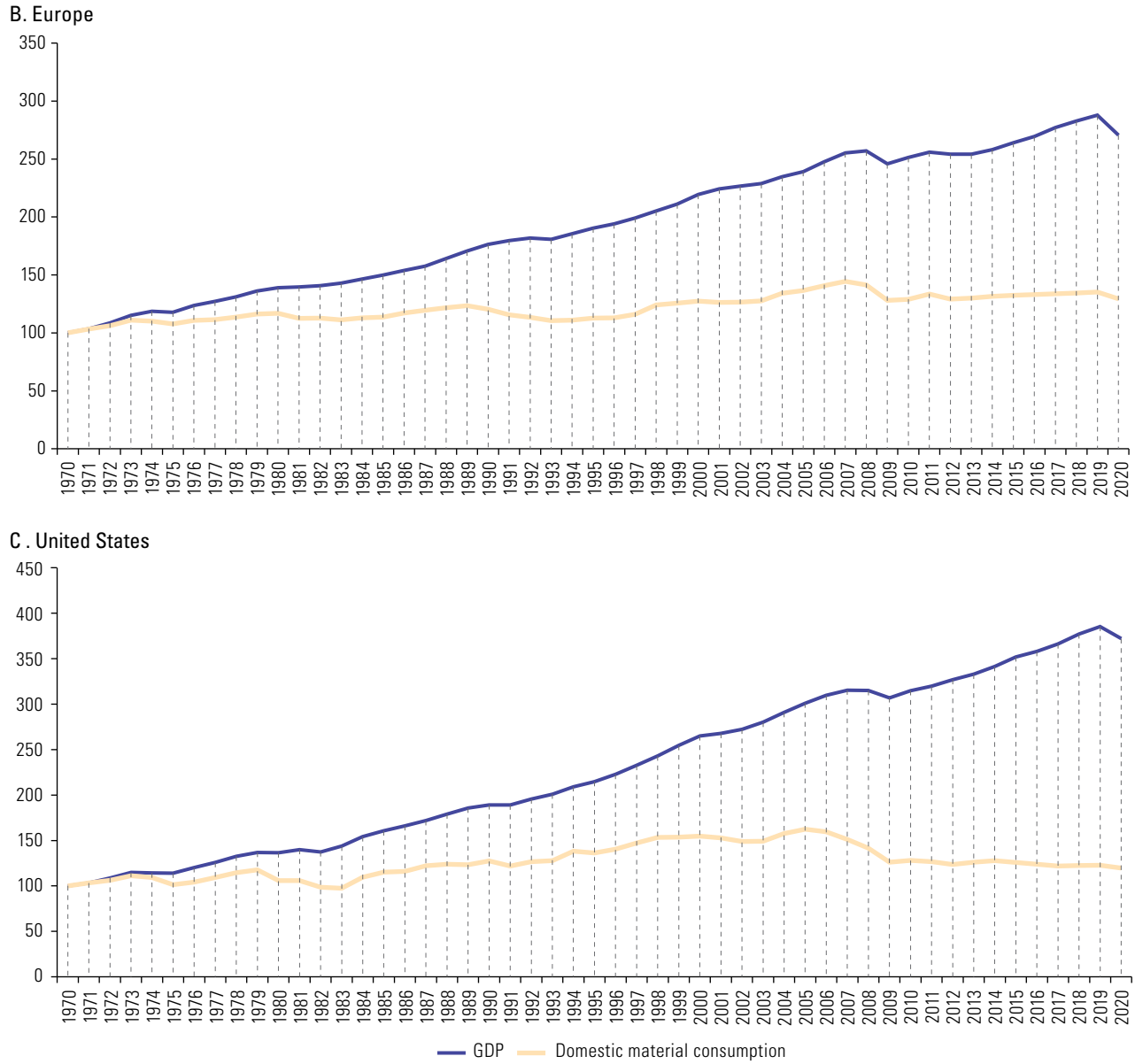


Figure IV.2 (concluded)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Environment Programme (UNEP), Global Material Flows Database [online] https://www.resourcepanel.org/global-material-flows-database.
Note: The data for 2018 and 2020 is estimated.

B. Beyond consumption: the importance of more sustainable production

Progress towards more sustainable production reinforces and is aligned with the broader concept of sustainable development, whose paradigm is based around simultaneously achieving economic growth, social progress and environmental protection in a balanced manner. This acknowledges that current trends in production and consumption will inevitably cause a shortage and depletion of natural resources, with negative and unexpected consequences for society and humankind. In this context, it is necessary to drive technical and structural

change so that the production sector can reduce its environmental impact and, at the same time, promote a sustainable growth model (Rovira, Schaper and Patiño, 2017).

Changes to consumption patterns must be accompanied by changes to production patterns, as the development model could otherwise become unsustainable, with significant impacts on GDP, personal income and consumption capacity. This would reinforce a kind of "modernity as window-dressing", where consumption patterns reproduce dependency on technologies produced in developed countries and are not accompanied by changes to production patterns in developing economies (Rovira and Hiriart, 2014).

In Latin America and the Caribbean, the transition to more sustainable production systems is complicated. For one thing, the region is struggling to accelerate growth and reduce productivity and income gaps between it and the developed world, while also improving the quality of life of its citizens and ensuring access to basic goods and services. For another, a production structure based on static comparative advantages skews economic activities towards the use of natural resources and sectors requiring intensive use of energy (fossil fuels, in particular), water and materials. This bias produces negative externalities that harm the natural environment.

Added to these challenges is a high level of heterogeneity in business. There are many medium-sized enterprises with low productivity that are facing significant challenges in terms of their capacity for innovation and emphasis on exports, while struggling to access technology and funding. These features are central to the region's production structure and reinforce the difficulties faced by enterprises, in particular micro-, small and medium-sized enterprises, in responding to stricter environmental regulations, promoting changes in production and commercialization processes and investing in equipment and technology.

While the challenges in the transition to sustainable production models are varied, there are also a number of benefits. These include resource savings through the adoption of more efficient technologies in production processes. Moreover, sustainable production promotes the adoption of cleaner technologies and business strategies that encourage innovation and technological development. All of this has the potential to boost scientific and technological progress, promote new synergies and redirect investments towards a low-carbon growth trajectory with a better environmental performance.

Similarly, the production of more sustainable goods and services may lead to economic opportunities to access new markets with greater added value, taking advantage of the demand created by increased environmental awareness. These changes can drive innovation, entrepreneurship and job creation by generating value from solving environmental problems. In this context, there is conclusive evidence that there is an insufficient supply of environmental goods and services in the region. Companies are unable to address the needs arising from environmental or market regulation, as a result of which many of these technologies and services end up being imported (ECLAC, 2006).

The creation of new productive capacities and the adoption of clean technologies requires companies to promote environmentally responsible business strategies and find a balance in the inclusion of technology, knowledge and innovation in production processes, with the aim of moving towards a more inclusive and sustainable growth. Economies able to accept this new paradigm may find opportunities to not only reduce their environmental impact, but also to alter their sectoral composition and promote innovation and technology diffusion.

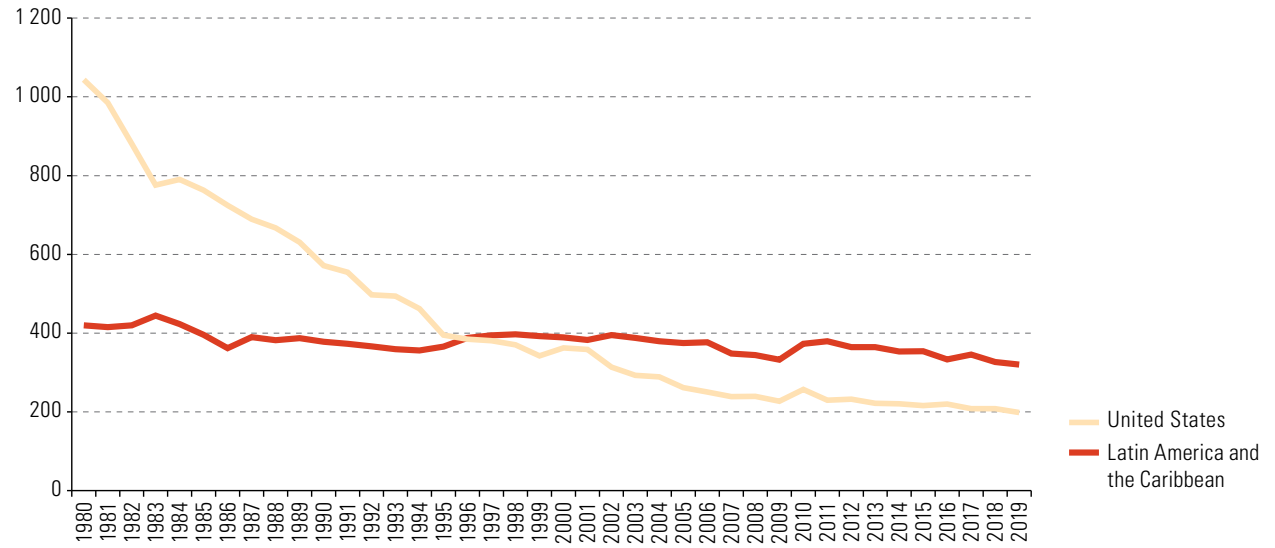
Sustainable production requires the continuous and consistent implementation of technological and industrial policies, which drives institutional coordination in various economic, productive and environmental areas. It also calls for agendas establishing concrete objectives and aims for companies' environmental practices in the short, medium and long term. It is therefore also essential that any such set of policy measures is based on an in-depth analysis of the environmental behaviour of the production sector. In this regard, monitoring and analysing progress in the various areas of sustainable production is key to understanding the state of national efforts to decouple economic growth from environmental impact.

1. The carbon intensity of industrial processes

The existing data suggest that when economies become industrialized, their environmental impact increases. However, when these economies reach a critical point in their level of development and their sectoral composition changes to activities based around service provision, their environmental impact is reduced. This shows an inverse relationship between income level and CO_2 emissions, although the correlation is not always linear. For example, in the case of Latin America and the Caribbean, despite the increase in income levels in recent decades, intensity indicators for materials, energy and CO_2 emissions have been stable. This is primarily because there is still little diversification in the production structure, which is extraction-based and has a low level of scientific and technological development. Such development enables the discovery of innovative solutions that transform production processes (ECLAC, 2018).

Reducing environmental impacts requires a structural and technical change that Latin America and the Caribbean has not yet achieved. Analysis of trends in the intensity of CO_2 emissions in the manufacturing sector shows that they have been at a standstill for decades in comparison to the levels of more advanced countries, such as the United States (see figure IV.3). It is clear that, in absolute terms, industrialized countries are responsible for the majority of global CO_2 emissions. Nonetheless, environmental efficiency efforts must be part of the economic agenda of all countries in order to create a sustainable trajectory over the medium and long term. There are various measures that can be taken in industry to tackle climate change without losing competitiveness. These include improving energy efficiency (which can be achieved through energy efficiency assessments and management systems), the use of renewable energies and the optimization of products and processes relating to CO_2 capture. In particular, the implementation of carbon capture and storage technologies can be a viable and vital option in efforts to reduce CO_2 emissions in industrial processes (IEA/UNIDO, 2011).

Figure IV.3
Latin America and the Caribbean: CO_2 emissions from manufacturing, 1980–2019
(Metric tons of CO_2 per US$ 1 billion of GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organisation for Economic Co-operation and Development (OECD), "CO_2 Emissions by product and flow" [online database] https://www.oecd-ilibrary.org/energy/data/iea-co2-emissions-from-fuel-combustion-statistics/co2-emissions-by-product-and-flow_data-00430-en.

2. Environmental productivity of resources: water in industrial processes

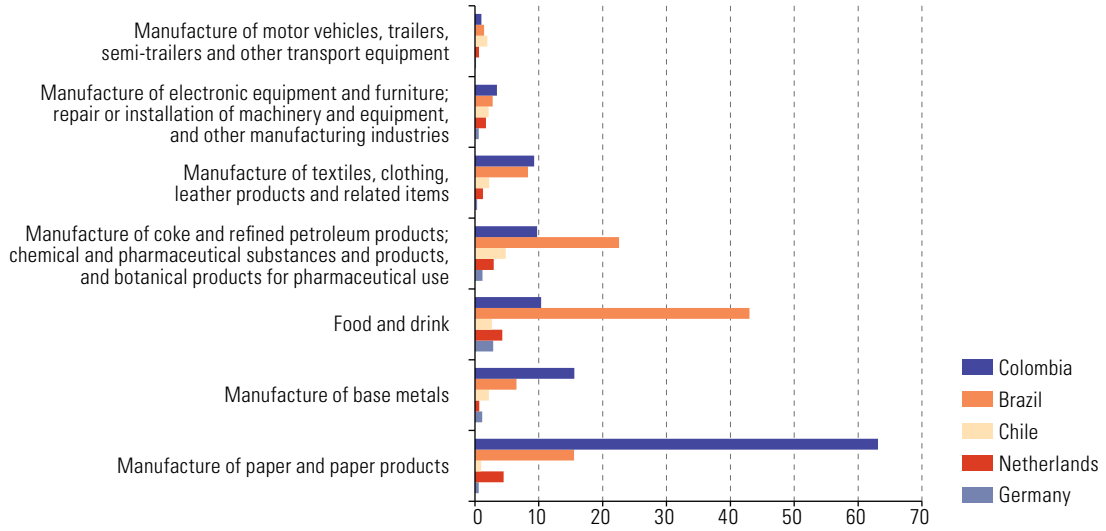
Sustainable production is characterized by efficiency in the use of raw materials. We often refer to consumptive use, understood as use intended for production processes, in which case the resource does not return to the environment whence it was extracted. The use of water is a clear example of consumptive use of a resource in a production process (Rovira, Schaper and Patiño, 2017). In the specific case of water, this resource is not only essential to the production process but is also a scarce resource that is vital to humans and the natural environment. Unnecessary consumption of water in business activities leads to reduced availability of water for other purposes. Many countries are already facing a growing gap between the supply of water and demand for it. According to UNESCO (2019), more than 2 billion people live in countries with high levels of water stress.

Water treatment in the industrial sector is critical to sustainable production. This is not only because of its share of the current total demand for this resource, but also because of the expectation that it will grow considerably in the coming decades, linked largely to the expansion of manufacturing activities. Global estimates indicate that demand for water in the manufacturing sector will triple between 2020 and 2050, increasing from 578 billion m3 to 1.552 trillion m3 (OECD, 2019). In addition, the cost of water is increasing owing to quality standards, stricter environmental regulations and a lack of water treatment capacities. For this reason, water management is a crucial part of sustainable production for companies.

Analysis of the intensity of water consumption of a group of subsectors in the industrial sector shows significant differences between countries. This clearly illustrates that some activities make much more intensive use of this resource than others. For example, manufacturing paper products, base metal products and food and drink products consumes much more water than the manufacture of motor vehicles and electrical equipment. Moreover, it reveals that countries such as Brazil and Colombia have high intensity water use in comparison to countries such as Germany and the Netherlands. In the case of Chile, indicators of water-use intensity show behaviour closer to that of the European countries included in this analysis. Chile has lower values in subsectors such as the manufacture of paper and related products in comparison to countries such as the Netherlands, and in food and drink products in comparison to Germany (see figure IV.4).

As with other resources, many of the opportunities to improve efficiency in demand for water are linked to economic incentives and reducing costs. While water-related costs may vary by industry, estimates suggest that they may account for 6% of production costs. Water management solutions can also vary in line with costs and the level of corporate commitment, but primarily involve improving waste management and wastewater treatment and making changes to the production process, as well as other more expensive actions that require systematic analysis of how to reduce water use and the associated costs (Puigjaner, Espuña and Almató, 2000). For this reason, it is necessary to increase awareness of water treatment, develop monitoring processes that provide reliable and comparable information for decision-making, and share success stories and best practices, as well as carry out reviews in order to redesign processes and incorporate technology into specific processes.

Figure IV.4
Water-use intensity
(Cubic metres per US$ 1 billion of added value)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of National Administrative Department of Statistics (DANE), National Institute of Statistics (INE), Brazilian Institute of Geography and Statistics (IBGE); National Water Agency (ANA), Água na industria: uso e coeficientes técnicos, Brasilia, 2017; European Commission, Eurostat [online database] https://ec.europa.eu/eurostat.

Note: The information on Brazil is from 2015; the information on Germany, Colombia and the Netherlands is from 2016; and the information on Chile is from 2017 and does not include the coke and refined petroleum products sector.

C. Harnessing eco-innovation and technological change to drive more sustainable production

Eco-innovation is the search for more sustainable production models. This term is linked to business capacities to improve efficiency in the use of natural resources and reduce pollution by incorporating new organizational and commercial processes, products and practices that are more environmentally friendly. These changes lead to positive externalities based on the demand for environmental goods and services, which translates into opportunities for entrepreneurship and sources of employment (Álvarez, Fernández and Romera, 2014).

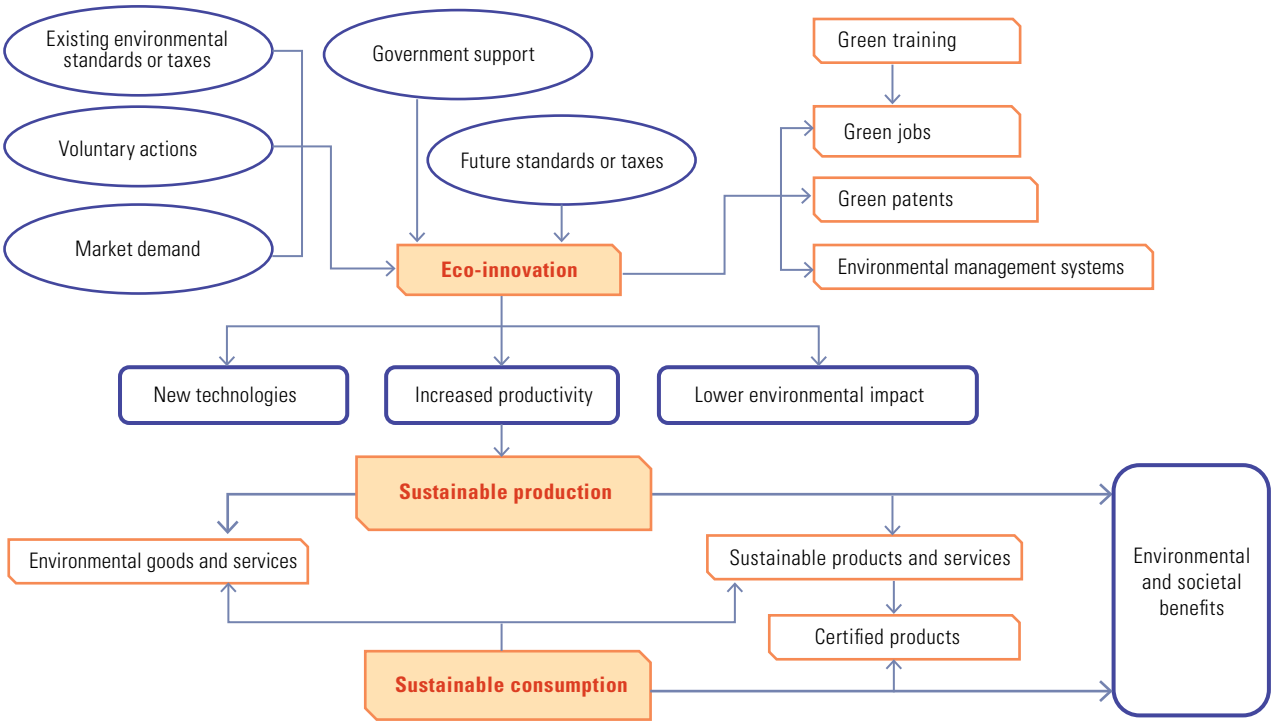
Environmental discourse has moved beyond to business world to become part of innovation strategies. In this case, such strategies promote new ways of doing business and emphasize the need to improve the productivity of resources. The growing demand linked to compliance with (ever stricter) environmental regulations and the importance of reducing costs has also boosted efforts intended to increase energy efficiency, reduce waste, promote recycling and optimize packaging.

It becomes ever clearer that expectations concerning consumption and quality of life can only be achieved sustainably if economic production is greatly expanded per, for example, ton of copper, hectare of land or barrel of oil. In sum, the need to save resources has entailed a shift from environmental solutions at the end of a product's life to others that prioritize environmental performance throughout its life cycle. This has even encouraged closed production cycles and the reuse of products at the end of their useful life. Ultimately, these new approaches and business models, which also incorporate significant innovations and technological developments, increase the productivity of resources.

There are various factors that influence eco-innovation, the expected areas of impact (productivity, innovation, lower environmental impact) and their relationship to other concepts, such as production and sustainable consumption (see diagram IV.1). The introduction of new technologies may promote the development of new production activities of environmental goods and services and an increase in employment as a result of

these activities, known as green jobs. This requires industrial, technological, innovation and training policies that contribute to progress towards sustainable consumption and production models in the region. This is undoubtedly key to a transformative recovery in Latin America and the Caribbean.

Diagram IV.1
Determining factors in eco-innovation and their relationship with sustainable production and consumption



Source: Economic Commission for Latin America and the Caribbean (ECLAC).

The determining factors in eco-innovation and how it differs from other innovations have been analysed in various studies (Porter and Van der Linde, 1995; Rennings, 2000). In short, as well as the "market pull", "technology push" and the specific features of a given business, eco-innovations are primarily determined by "regulatory push–pull". Environmental regulations and policies may thereby have an impact on the negative externalities of business activity by imposing limits on certain activities (for example, greenhouse gas emissions or the use of pollutants). On the other hand, they may act as demand-side incentives and policies (for example, subsidies, public procurement) (Rovira, Schaper and Patiño, 2017).

While eco-innovation is a broad term, which includes all innovations with an environmental objective, whether organizational or related to a process or product, it can generally be examined by considering four major areas: inputs, direct products, indirect products and impacts (Machiba, Bonturi and Pilat, 2009). In the case of Latin America and the Caribbean, the environment for promoting innovation in general, and environmental innovation in particular, remains weak. This conclusion arises from analysis of the general and specific resources allocated to these aims by countries in the region, which results in a lower rate of creation of environmental innovations (Cleantech Group and others, 2017).

1. Inputs and capacities for eco-innovation

As mentioned previously, Latin America and the Caribbean's performance in investment in research and development (R&D) is weak, especially in comparison to the dynamic seen in other more advanced or emerging regions.

This reveals the lack of a strategic vision that identifies science, technology and innovation as key factors in regional development. However, this is also caused by more deep-rooted factors, such as the sectoral composition of this investment as a result of a production structure ill-suited to research and science. For example, while in advanced countries the main source of funding is the private sector, in Latin America and the Caribbean it is the public sector that is the biggest contributor of R&D funding.

On the other hand, analysis of public R&D efforts with environmental aims reveals a high level of heterogeneity in countries in the region. Some countries, such as Mexico and Costa Rica, allocate proportional values on a par with, or higher than those of more advanced countries, such as Spain and the United States. The Latin American and Caribbean countries for which there is information spend an average of 5.22% of their R&D budgets on environmental monitoring and protection. However, taking into account the total environmental R&D expenditure in relation to GDP, it is clear that more advanced countries allocate a greater share of their GDP to spending on environmental R&D (see table IV.1).

Table IV.1
Latin America and the Caribbean (8 countries), Spain and the United States: public expenditure on R&D with environmental objectives (environmental monitoring and protection) in relation to GDP, most recent available year
(Percentages)

Country	R&D expenditure on environmental monitoring and protection as a percentage of total R&D expenditure	R&D expenditure on environmental monitoring and protection as a percentage of GDP
Argentina	5.39	0.030
Chile	0.59	0.002
Costa Rica	9.62	0.044
El Salvador	1.65	0.002
Guatemala	0.01	0.000003
Mexico	9.18	0.036
Paraguay	1.07	0.001
Trinidad and Tobago	14.29	0.013
Spain	5.44	0.068
United States	7.30	0.123

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Ibero-American Network on Science and Technology Indicators (RICYT) and Organisation for Economic Co-operation and Development (OECD), OECD.Stat [online database] https://stats.oecd.org/.

Note: Data for Argentina, Costa Rica, El Salvador, Mexico and Trinidad and Tobago are from 2016. Data for Chile are from 2017. Data for Spain, Guatemala and Paraguay are from 2019, and for the United States from 2018. In Spain, the expenditure disaggregated by socioeconomic objective does not include the business sector; since 2004, the series has been reviewed by the Ministry of Science and Innovation using the new Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS) classification. In the United States, since 2006, there has been a change in classification by socioeconomic objectives. In El Salvador, the data reported as science and technology expenditure correspond to spending by the higher education and government sectors. In Guatemala, the information reported corresponds to spending by the government and higher education sectors. In Mexico, the information reported as expenditure on science and technology activities refers only to federal spending on science and technology.

2. Intermediary products in eco-innovation

When examining patenting behaviour around the world, we can see that many countries are directing their innovation efforts towards areas related to environmental protection, such as environmental pollution, water and mitigating climate change. Most innovations and patent filings in this area (including on renewable energies, electric and hybrid vehicles, energy efficiency in buildings, and water and waste treatment) take place in more advanced countries, such as the United States, Japan and European countries. For example, between 2010 and 2018,

on average, 50 times more environmental patents were filed per year than in the whole of Latin America and the Caribbean. This difference is also significantly bigger in comparison to countries such as Germany, Japan and the Republic of Korea. However, we should also call attention to the fact that the region doubled its number of patents in this area between 2000 and 2009, and 2010 and 2018. In addition, proportionally, the share of environmental patents in the total figure is higher in Latin America and the Caribbean than in the United States and China (see table IV.2).

Table IV.2
Total and environmental patents per million inhabitants

Region or country	Average 2000–2009			Average 2010–2018		
	Total	Environmental	Environmental patents out of the total number of patents (*percentage*)	Total	Environmental	Environmental patents out of the total number of patents (*percentage*)
World	89.2	7.0	7.8	91.9	9.9	10.7
OECD	388.9	31.3	8.0	430.8	48.9	11.4
United States	520.7	33.8	6.5	541.4	48.5	9.0
Republic of Korea	1,821.8	148.7	8.2	2,401.2	303.5	12.6
Japan	624.0	59.0	9.5	706.9	90.5	12.8
Germany	637.3	66.0	10.4	677.7	96.6	14.3
China	46.2	3.6	7.7	35.4	2.9	8.2
Latin America and the Caribbean	4.3	0.4	9.6	10.5	1.1	10.7

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of European Patent Office (EPO), Worldwide Statistical Patent Database (PATSTAT) [online] https://www.epo.org/searching-for-patents/business/patstat.html.

It is also important to highlight that the region has the capacity to lead technological innovation processes by harnessing its natural resources. There are clear examples of this in the field of biofuels, where Brazil has set a technological benchmark. Its activities were strengthened by the National Alcohol Programme (Proalcohol), created in the 1970s, which contributed to boosting bioenergy production in the country. This programme is one of the major Brazilian success stories in science and technology and is a case where synergy between academia, research institutions, the Government and the business world has achieved positive results (ECLAC, 2013).

There are also companies producing innovations with environmental aims that are based around natural resources. This is case of Biofase in Mexico, which, since 2014, has produced bioplastics using avocado seeds. These bioplastics decompose in only 240 days, which makes them a sustainable solution to the alternative of burning waste. Biofase products have great manufacturing potential. According to Biofase, 300,000 tons of avocado seeds are thrown away in Mexico every year, which could meet 20% of the global demand for bioplastics. Biofase has customers in 11 Latin American countries (UNEP, 2019).

3. Eco-innovation activities and environmental certifications in companies

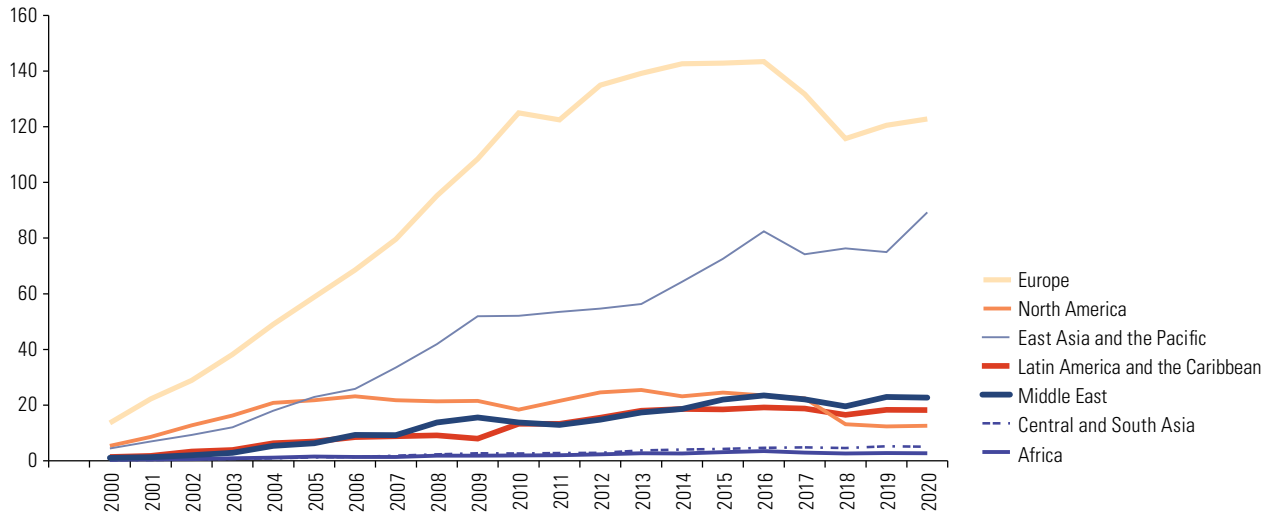
Voluntary environmental certifications, such as the ISO 14001 standard, are an indicator of an enterprise's environmental responsibility. It is a standardized international procedure on the design and implementation of environmental management systems that help to organize, identify, manage, monitor and control environmental impact.[2]

[2] It is important to note here that, by creating a system that identifies its own monitoring and control measures, the ISO 14001 standard has a limited ability to optimize the environmental performance of the certified organization.

At the global level, the dissemination of environmental management standards, such as the ISO 14001 standard, is linked to supply and demand factors in international markets, as well as institutional aspects of both the company and the sector and country in which it operates (Bodas and Iizuka, 2008; Neumayer and Perkins, 2004). As regards international markets, the ISO 14001 standard is recognised for its capacity for guidance in areas including environmental responsibility, organizational culture and management and production techniques. This type of certification acts as an entry control for international markets. Its guidance capacity is particularly useful for enterprises operating in contexts with little regulation and low expectations in terms of management and production, as is the case in many Latin American and Caribbean countries (Bodas and Iizuka, 2008).

Between 2000 and 2020, the number of ISO 14001 certifications worldwide grew from 23,006 to 348,473 per year, an average annual increase of 16%. For 2020, the regions with most certifications were Asia and the Pacific (60%) and Europe (30%), and the number of certifications per million inhabitants in these two regions was 89 and 123 respectively. During the same period, the number of certifications per year in Latin America and the Caribbean rose from 715 to 11,878, with an average annual growth rate of 18%. For 2020, the region's share of the total number of certifications worldwide was around 3%, with 18 certifications per million inhabitants (see figure IV.5).

Figure IV.5
Distribution of ISO 14001 certifications in the various regions of the world, per million of inhabitants, 2000–2020
(Number of certifications)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Organization for Standardization (ISO), "ISO Survey of certifications to management system standards: full results" [online database] https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1.

Regional difference in the adoption of the standards of the International Organization for Standardization (ISO) are partially explained by the promotion and institutional support enjoyed by such certifications, as well as by standard practice in implementing environmental management systems. For example, in Europe there are institutions and certifications (such as the Eco-Management and Audit Scheme) that promote environmental responsibility and thereby contribute to reducing the costs associated with implementing the certifications (Neumayer and Perkins, 2004). In Latin America and the Caribbean, there are empirical data for a group of countries on the positive correlation between the number of ISO 14001 certifications and their global linkages. Towards the end of the 1990s, following the consolidation of the opening-up of trade in the region, the number of certifications increased to a rate higher than in the rest of the world (ISO, 2005). However, in order to fulfil the requirements of the certifications, it is necessary for enterprises to have a developed technological and institutional infrastructure at the sectoral and national levels (Bodas and Iizuka, 2008).

At both the global and regional levels, the highest number of certifications is in the construction sector (see table IV.3). This may be linked to the sector's high environmental impact. Estimates suggest that construction products are responsible for approximately 30% of the environmental impact in key categories such as global warming, toxicity to humans, abiotic depletion and the shrinkage of the ozone layer (Marimon, Llach and Bernardo, 2011).

Table IV.3
Latin America and the Caribbean and the rest of the world: distribution of ISO 14001 certifications by economic sector, 2017–2020
(Percentages)

Latin America and the Caribbean		Rest of the world	
Construction	11.08	Construction	16.15
Transportation, storage and communications	9.83	Wholesale and retail trade; vehicle repair	9.01
Other social services	6.99	Base metals and associated products	8.32
Base metals and associated products	6.96	Electrical and optical equipment	8.23
Engineering services	6.03	Engineering services	5.75
Chemical substances and products and fibres	4.80	Machinery and equipment	5.29
Food, drink and tobacco products	4.72	Other social services	5.03
Electrical and optical equipment	4.40	Plastic and rubber products	4.26
Wholesale and retail trade; vehicle repair	3.96	Chemical substances and products and fibres	3.37
Machinery and equipment	3.71	Information technologies	3.25

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Organization for Standardization (ISO), "ISO Survey of certifications to management system standards: full results" [online database] https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1.
Note: This includes 25 Latin American and Caribbean countries.

As regards Latin America and the Caribbean, timely political support and private and public collaboration are needed to develop innovative technologies and institutional infrastructures. This would make it possible to keep pace with international standards, foster national involvement in relevant discussions, in both low- and high-tech industries, and facilitate the development of business and sectoral capacities. All of this ultimately leads to increased international competitiveness (Bodas and Iizuka, 2008).

One of the major barriers to greater knowledge of eco-innovation processes in the region is a lack of data and statistics that take into account the adoption of environmental practices in companies. Despite this situation, there are a number of isolated initiatives intended to boost data collection in this area. One of them has been the incorporation of specific eco-innovation-related questions in the Survey of Innovation (PINTEC) of the Brazilian Institute of Geography and Statistics (IBGE) (see box IV.1). The available information for Brazil shows the differences in the number of companies that implement eco-innovation practices by their size. This highlights the difficulties that many companies face in increasing such practices and the challenges smaller companies face in trying to become part of a more sustainable production system.

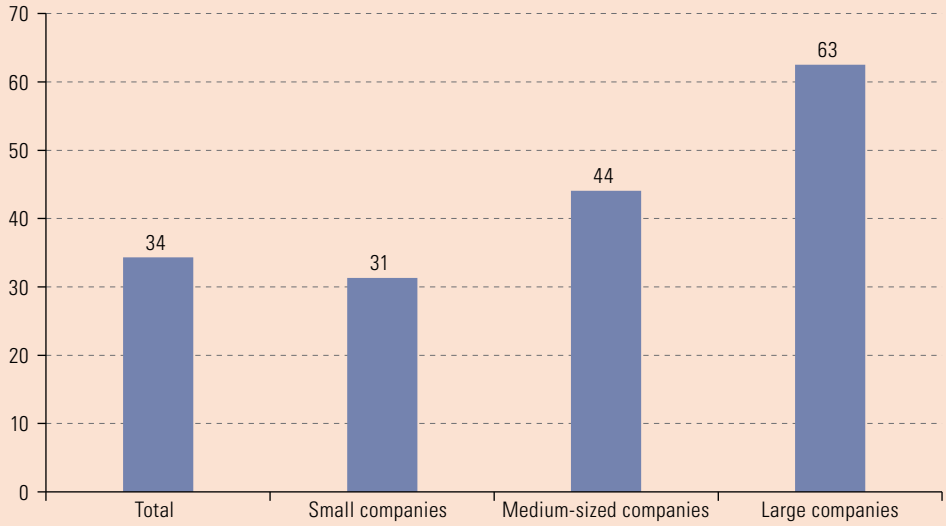
Box IV.1
Results of the Brazilian Survey of Innovation

According to the available data from the Survey of Innovation (PINTEC) of the Brazilian Institute of Geography and Statistics (IBGE), there is a large difference between the percentage of small companies (11 to 49 employees) that implement eco-innovations and large companies (over 250 employees).

As regards the importance afforded by manufacturing companies to the impacts of their innovations, the most significant impacts appear to be recycling waste, wastewater or materials, and reducing soil, water and air pollution, as well as noise pollution. Those considered less important were those relating to the replacement of raw materials with less polluting materials, the reduction of CO_2 footprints and the replacement of fossil fuels with renewable energies.

Box IV.1 (concluded)

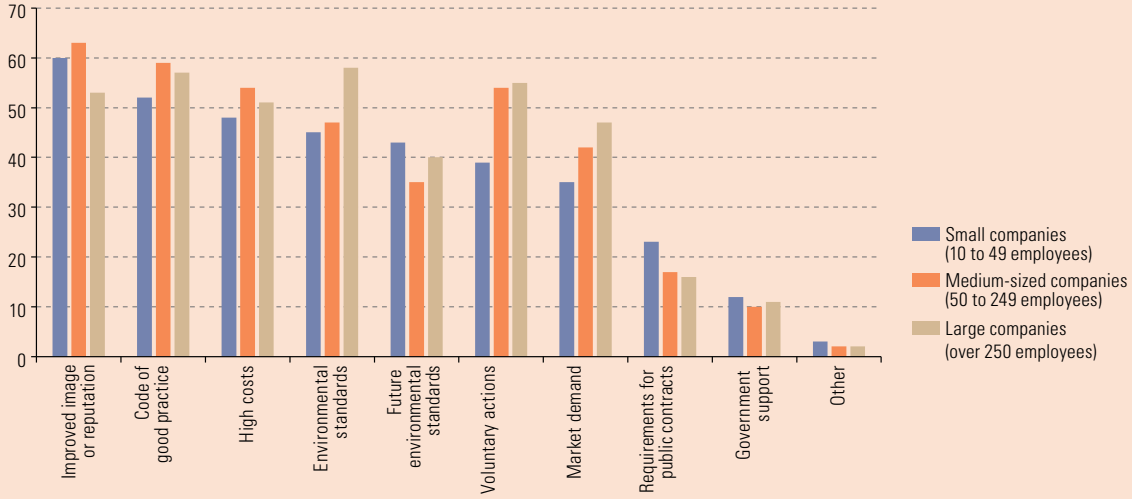
Manufacturing companies that carry out eco-innovation, by size, 2015–2017
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC) and Brazilian Institute of Geography and Statistics (IBGE), Pesquisa de inovação: 2017, Rio de Janeiro, 2020.

The following figure shows the distribution of the various factors that prompted Brazilian manufacturing companies to undertake eco-innovation activities in the period 2015–2017, by size. In the case of small companies, the main factors identified were an improvement to their image or reputation (60%), compliance with existing codes of good practice (52%), high production costs (48%) and compliance with existing (45%) and future (43%) environmental standards. In the case of medium-sized and large companies, factors relating to market demand and voluntary action were more important than for small companies. In all companies, irrespective of their size, the most influential factors were compliance with requirements in public contracts and existing governmental support.

Factors influencing the introduction of eco-innovations into manufacturing companies, by company



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Brazilian Institute of Geography and Statistics (IBGE), Pesquisa de inovação: 2017, Rio de Janeiro, 2020.

Source: Economic Commission for Latin America and the Caribbean (ECLAC) and Brazilian Institute of Geography and Statistics (IBGE), Pesquisa de inovação: 2017, Rio de Janeiro, 2020.

D. Policies and instruments to foster eco-innovation and more sustainable production

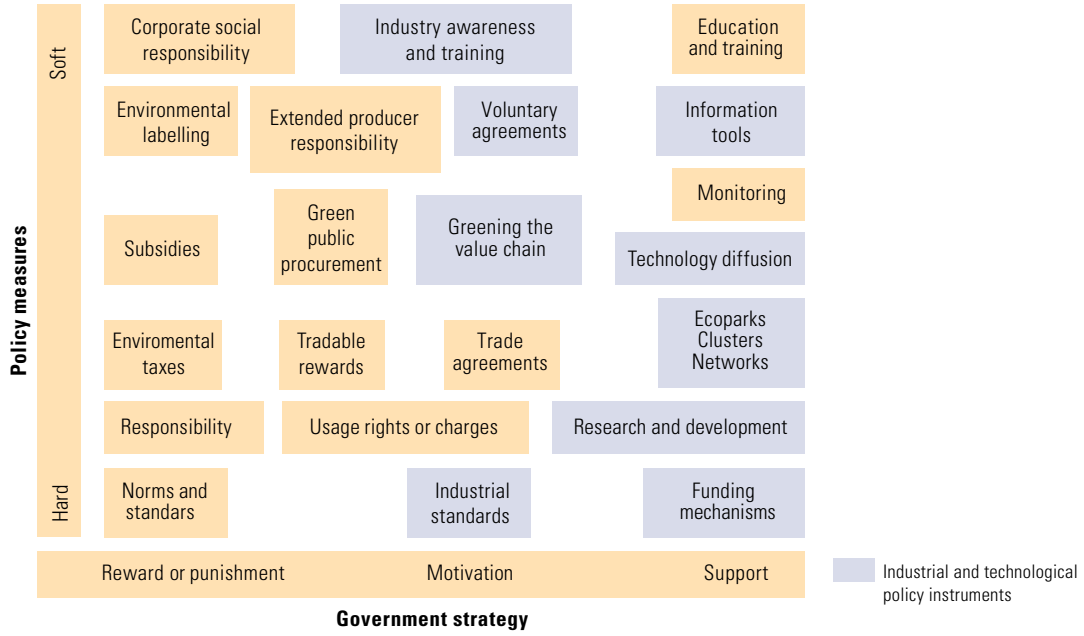
There are various elements that drive change in production and consumption patterns towards greater sustainability. Increasing environmental awareness is motivating companies to acquire strategies to reduce their environmental impact, primarily in response to consumer demand in more developed countries for products and services that take environmental responsibility into account. Moreover, local communities are also exerting pressure to ensure respect for their natural ecosystems where some companies operate. These trends, couple with stricter environmental regulations and standards, are inspiring varied strategies at the company and industrial levels.

However, in recent years, industrial efforts and strategies to achieve more sustainable production have stopped focusing on solutions at the end of a process or a product's life cycle, and are now aimed at preventing unwanted impacts by modifying products and production processes. The trend is continuing with instruments intended to improve environmental management systematically by extending environmental responsibility throughout the supply chain. Ultimately, the aim of this is to restructure production methods and integrate production systems through industrial parks and partnerships that make it possible to create synergies to reduce environmental impacts (UNIDO, 2011).

An important part of environmental legislation continues to be a command and control approach. Even then, the effectiveness of such measures can be reduced because of the availability of financial and technical resources to implement them. At the other extreme are instruments intended to promote change in business practices by means of incentives. Such mechanisms promote innovation and the adoption of more efficient technologies to improve productivity and create economic opportunities.

Below is a useful diagram that shows the various policy instruments that may form a sustainable production strategy. Actions may be obligatory or voluntary. In the top left are measures linked more to incentives than to sanctions. In the bottom left are obligatory measures and those linked to environmental taxes and to norms and standards. Instruments relating to technology and innovation policies are found among voluntary support instruments, such as training, technology diffusion, access to funding, standard-setting and information tools (see diagram IV.2).

Diagram IV.2
Policy matrix for a greener industry



Source: United Nations Industrial Development Organization (UNIDO), Green Industry: Policies for Supporting Green Industry, Vienna, 2011.

In practice, meeting sustainable production objectives requires an integrated approach to policy development, in contrast to traditional sectoral approaches. In many cases, the environment is the responsibility of a single institution. This is true of most countries where there is one specific competent body in this area, whether at the ministerial level, internally within a ministry or within the framework of an environment-related public service. However, there are some countries that, apart from having a relevant governmental body, have created committees or commissions with representatives from different areas of government to take responsibility for developing public policies on sustainable production and consumption at the national level (Rovira, Schaper and Patiño, 2017).

Since the start of public intervention in science, technology and innovation, practical instruments have developed to include technological funds, sectoral funds, venture capital stimuli, cooperation initiatives between universities and enterprises, sustainable public procurement and networks. The environmental dimension unquestionably also adds a new element of complexity to these initiatives. In order to respond to these demands and move towards a greener growth model, it is undoubtedly necessary to define a comprehensive and cross-cutting framework for action, as well as for joint work and dialogue between the government, the private sector and civil society. While there is no one solution, a clear political commitment and certain elements of institutional innovation are required (Rovira and Hiriart, 2014).

Many Latin American countries have adopted some type of initiative linked to sustainable production and consumption. They have also approved legislation and regulations on environmental impact assessment, land planning, new offenses and sanctions, and responsibility for environmental damage and legal actions aimed at environmental protection, taking into account the creation of competent authorities in this area. Moreover, there are some ongoing initiatives that incorporate development and technology diffusion policies with an environmental objective. Some of these initiatives on technology diffusion and support for capacity-building are being pursued in national programmes and centres for clean production (see table IV.4). These centres provide various services relating to raising awareness and disseminating information, training and technical assistance, assistance in developing national instruments and policies and technology transfer. These centres have also established strong links with various national bodies, such as chambers of commerce and industry, business associations, universities, trade unions and enterprises. Below is an overview of the clean production centres in the Latin American Network of Cleaner Production.

Table IV.4
Latin American Network of Cleaner Production

Country	Centre
Bolivia (Plurinational State of)	Center for the Promotion of Sustainable Technologies (CPTS)
Brazil	National Center for Clean Technologies (SENAI)
Colombia	National Center for Cleaner Production and Environmental Technologies (CNPMLTA)
Costa Rica	National Cleaner Production Centre (CNPML)
Cuba	National Network of Cleaner Production (RNPML)
Ecuador	Ecuadorian Center for Resource Efficiency and Cleaner Production (CEER)
El Salvador	Cleaner Production National Center (CNPML)
Guatemala	Guatemala National Cleaner Production Centre (CGP+L)
Honduras	National Cleaner Production Centre of Honduras (CNP+LH)
Mexico	Mexican Center for Cleaner Production (CMP+L)
Nicaragua	Nicaraguan Cleaner Production Center (CPmL-N)
Peru	Center for Eco-efficiency and Social Responsibility (CER)

Source: United Nations Industrial Development Organization (UNIDO) and others, Red Latinoamericana de Producción más Limpia: Informe 10 Años, 2016 [online] https://www.recpnet.org/wp-content/uploads/2016/08/10-a%C3%B1os-RECPnet-LAC-report.pdf.

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Science, innovation, knowledge and digital technologies have played a fundamental role in the growth potential, social inclusion and environmental sustainability of countries in recent decades, and have become even more important in the context of the crisis caused by the coronavirus disease (COVID-19) pandemic.

While Latin American and Caribbean countries have adopted various measures —many of them based on access to technology— to tackle the effects of the pandemic, the region's structural challenges have become more pronounced, and the need for more comprehensive, complex, participatory and capable innovations systems more evident. This document identifies the areas where efforts should be focused to make progress towards new, more inclusive and sustainable development strategies in which science, technology and innovation are key players for a transformative recovery.

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