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Cooperation, integration and regional challenges

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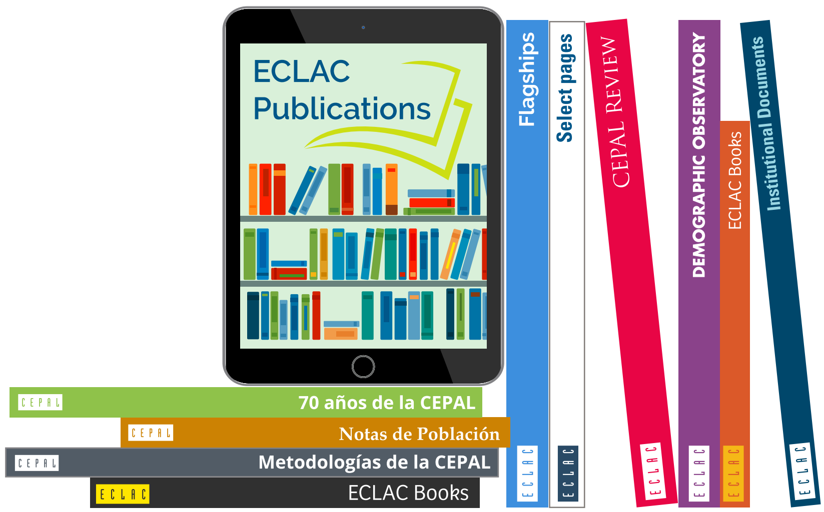

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Introduction and main messages

This document is intended as a contribution to the regional dialogue in the context of the meeting of Ministers and High Authorities of Science, Technology and Innovation of the Community of Latin American and Caribbean States (CELAC).

Its main message is that science, technology and innovation (STI) policies have a central role to play, not only in building national capacities for research and development, but also in solving national problems and challenges as part of countries' development policies.

National science, technology and innovation systems in Latin America and the Caribbean remain relatively weak compared to more developed countries —and even in comparison to some emerging economies— and there are notable differences from one country to the next.

The region's spending on research and development as a share of GDP is low and it is mainly financed by the State and spent by the academic sector. As a corollary to that, basic and applied research predominates over experimental development.

Although significant progress has been made with the institutional framework to support STI in recent years —either through the creation of dedicated ministries or the strengthening of specialized institutions— science, technology and innovation do not play a prominent role in productive and social development policies or in countries' budgets.

The battery of policy instruments for supporting science, technology and innovation seems incomplete and insufficient to generate significant momentum in this area. The widespread and practically exclusive use of demand-driven competitive funds has resulted in a wide dispersion of projects with low funding, the prioritization of short-term projects subject to political cycles and a focus on areas that address neglected national challenges.

In recent years, policymakers in Latin America have begun to realize that STI cannot be seen in isolation from other issues of concern to governments and society in general. Addressing many of the challenges facing the region's societies, in both the public and private spheres, requires deploying a scientific and technical perspective, since these are increasingly complex problems.

In a context of structural weakness, resource scarcity and the need for scale to achieve results, the resources allocated to support science, technology and innovation —or at least part of them— must be channelled into areas of knowledge related to the main challenges the countries face.

Many countries, especially the advanced economies, have therefore begun to revitalize their industrial policies as regards complex, comprehensive and capable national innovation systems, which has allowed them to mobilize productive, technical and knowledge capacities to address major development challenges. In other words, priority is given to supporting STI that allows progress with solving specific challenges, albeit without neglecting the development of more general scientific capabilities to allow the expansion of the frontiers of knowledge. This approach requires interconnections between a range of actors —governments, academia, the private sector and civil society— as well as new institutional arrangements for coordinating and strengthening capabilities for formulating and managing policies.

In the view of the Economic Commission for Latin America and the Caribbean (ECLAC), the region must pursue a progressive structural change, in which the production and services structure is reoriented towards knowledge-intensive sectors with more rapidly growing levels of demand and employment. At the same time, the quality of natural resources and the environment, and of the services they provide, must be preserved.

In that context, STI must contribute to the development of sectors and activities that can catalyse the economy and society. Chapter two discusses four of those in greater detail: manufacturing industry for the health sector, energy transition, electromobility, and eco-innovation and sustainable production.

CHAPTER

I

General overview of science, technology and innovation (STI) in Latin America and the Caribbean

As already noted, national STI systems in Latin America and the Caribbean suffer from structural weaknesses compared to those in more developed countries, and even to those of some emerging economies. At the same time, the situation within the region varies greatly from one country to the next.[1]

A. Underfunded systems that are geared towards research rather than experimental development

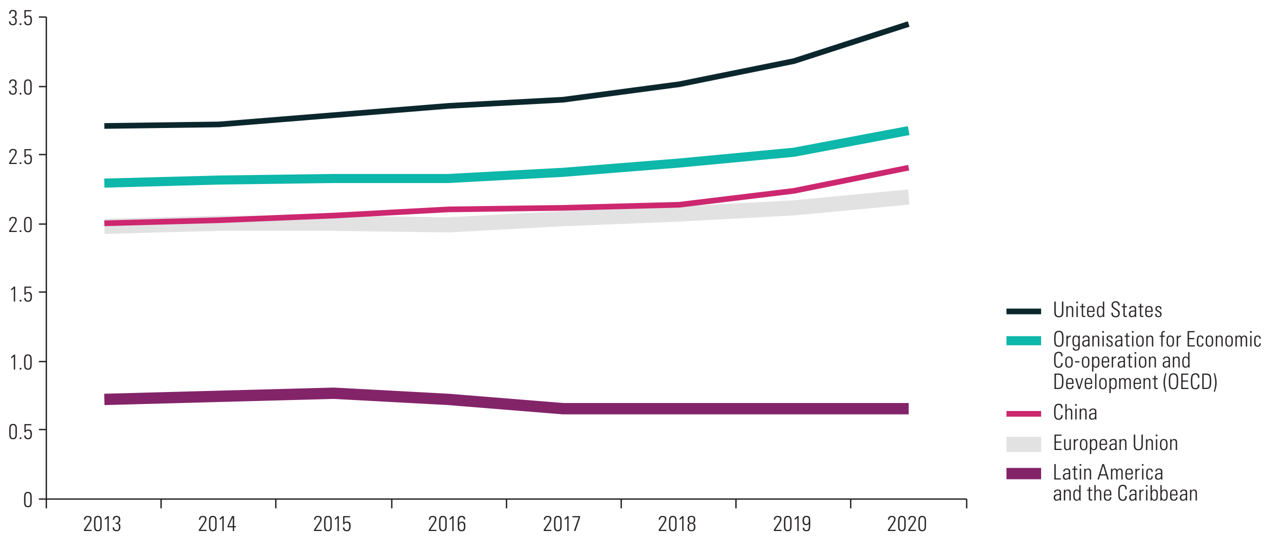
The region is clearly lagging behind in research and development (R&D) spending: not only with respect to the more developed countries, but also compared with some emerging economies, such as China. This gap has been increasing in recent years.

In the United States, the European Union, the countries of the Organisation for Economic Co-operation and Development (OECD) and China, R&D expenditure accounts for more than 2% of gross domestic product (GDP). That figure rises to 3.4% for the United States and to 4.8% for the Republic of Korea. Moreover, between 2013 and 2020, R&D spending relative to GDP in those countries and blocs increased by between 0.2 and 0.7 percentage points. In Latin America and the Caribbean, R&D spending as a share of GDP is about four times lower and, in addition, it fell from 0.72% of GDP in 2013 to 0.65% in 2020 (see figure I.1).

The situation within the region is not the same from one country to the next. In absolute terms, Argentina, Brazil and Mexico accounted for 86% of the region's R&D spending in 2020. Brazil alone accounts for 65% and, by allocating 1.17% of its GDP to R&D, also leads in relative terms. It is followed by Cuba, Uruguay and Argentina, with levels of around 0.5% (see figure I.2).

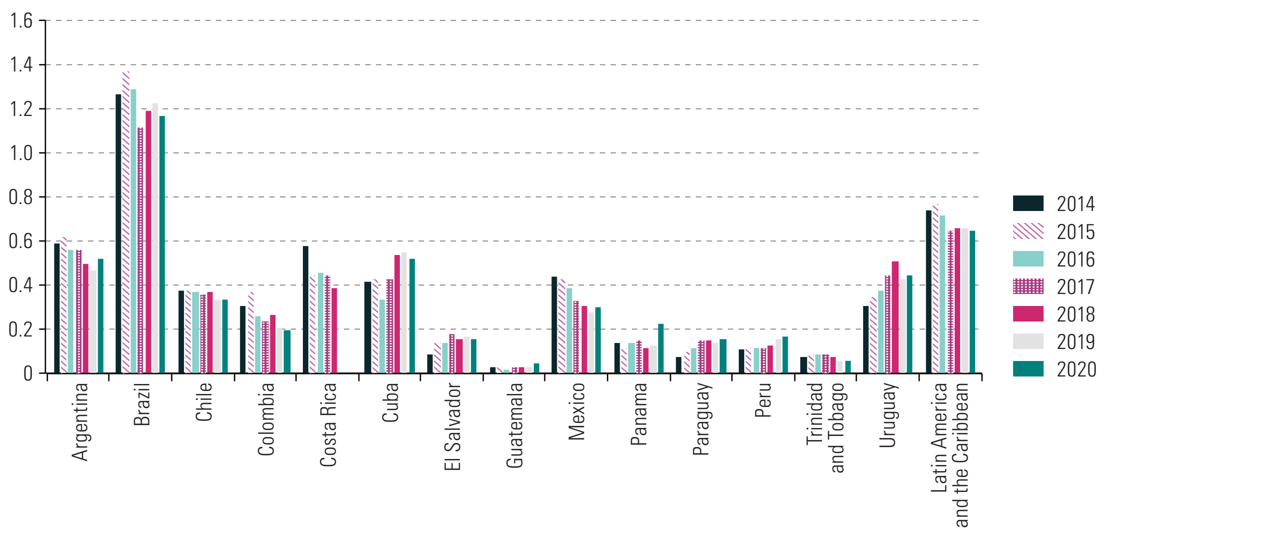
[1] This chapter is primarily based on the document *Innovation for development: the key to a transformative recovery in Latin America and the Caribbean* (LC/CCITIC.3/3) (ECLAC, 2022a) and on the conclusions of the third meeting of the Conference on Science, Innovation and Information and Communications Technologies of ECLAC, held from 13–15 December 2021 (ECLAC, 2022b).

Figure I.1
Latin America and the Caribbean and selected countries and blocs: research and development spending as a share of GDP, 2013–2020
(Percentages)



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

Figure I.2
Latin America and the Caribbean (14 countries): research and development spending as a share of GDP, 2014–2020
(Percentages)

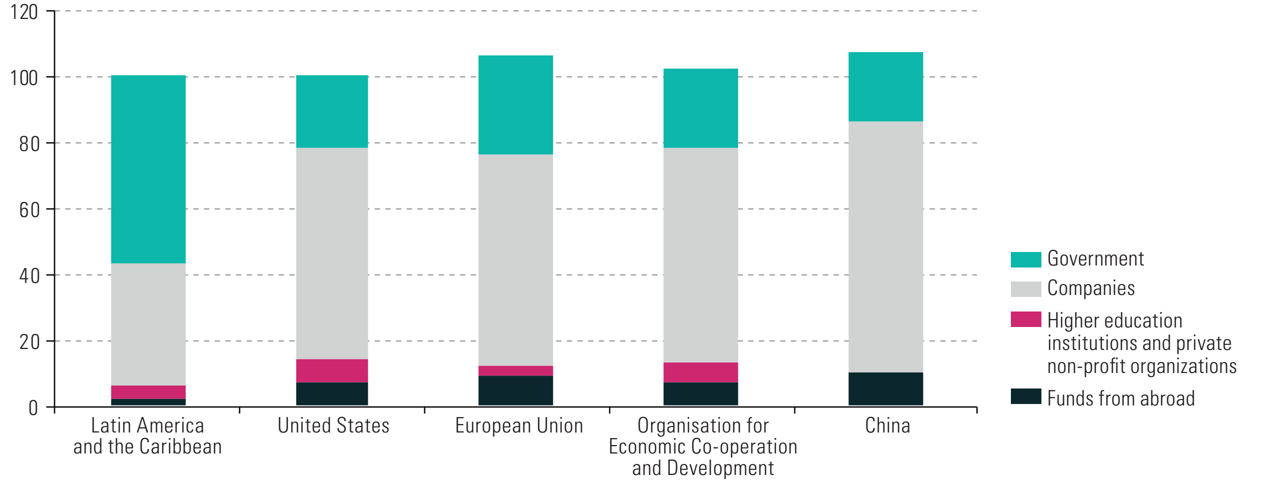


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Ibero-American Network of Science and Technology Indicators [online] http://www.ricyt.org.
Note: Data for Latin America and the Caribbean are estimates.

Latin America and the Caribbean maintains the financing and expenditure structure that has characterized it over recent decades. Most funding for R&D expenditure comes from the State, and this spending is mainly executed by the academic sector; this contrasts with the situation in more developed countries, where companies are the main entities that provide funding and allocate spending.

The business sector's share of R&D funding exceeds 60% in the United States, the European Union and the OECD member countries and stands at almost 80% in China. In contrast, in Latin America and the Caribbean, companies contribute around 35%, with the State providing 60% (see figure I.3). The fall in R&D spending in the region's countries is linked to declining government allocations, which fell from 62.5% of the total in 2013 to 56.5% in 2019.

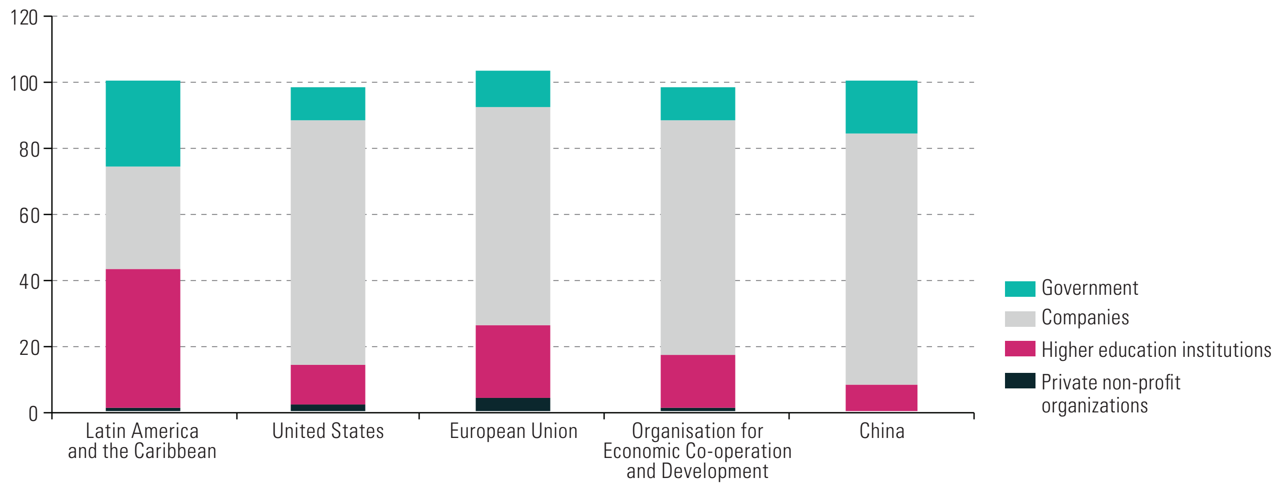
Figure I.3
Selected countries and blocs: research and development spending by source of funding, 2019
(Percentages)



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

In the region, the business sector accounts for a low share of R&D spending, with companies executing around 30% of the total. In comparison, in more highly developed economies, companies represent between 65% and 75% of the total. In the region's countries, universities play an important role in R&D, but mainly concentrate on basic research (see figure I.4).

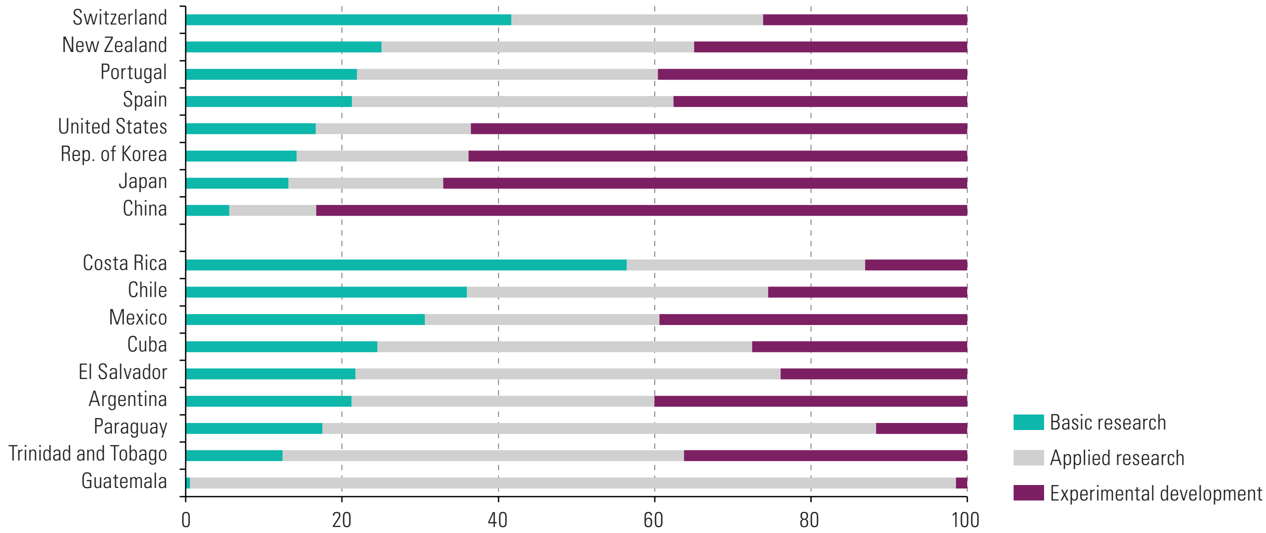
Figure I.4
Selected countries and blocs: research and development spending by executing sector, 2019
(Percentages)



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

Latin American and Caribbean countries spend most of their R&D funds on basic research, while experimental development predominates in more developed countries (see figure I.5). Consequently, in the region's countries, universities play a prominent role in R&D activities.

Figure I.5
Latin America and the Caribbean (9 countries) and other selected countries: research and development spending by activity type, around 2018
(Percentages)



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

B. Institutional support for STI has progressed but still suffers from weaknesses

Public institutions to support science, technology and innovation have evolved significantly in recent years. Several Latin American and Caribbean countries have introduced institutional changes, leading to the creation of ministries or other high-level political institutions in charge of this area.[2] Nevertheless, the creation of these new entities has not necessarily resulted in a more active role for STI in productive and social development policies.

This enhanced institutional status for science, technology and innovation has not been accompanied by budget increases and, in some cases, decreases have been recorded.[3] In addition, major modifications in priorities and policy orientation are common as a consequence of administrative changes made by new governments. Finally, their remits are not always explicit policies set out in a formal document, but rather a series of measures of different kinds that governments have adopted over time. Frequently, the support instruments in force must be reviewed so that policy can be inferred from them.

In the region, the most common STI support mechanisms involve granting subsidies —generally based on the competitive fund model— and higher education scholarships to support the training of human resources. Novel instruments have also been implemented, but not uniformly across all the countries (see table I.1).

2 In 13 of the 21 countries analysed there is a ministry, a ministerial-level agency or an executive branch body that is responsible for STI policy.

3 There may be many reasons for this, but one reasonable hypothesis invokes a fiscal panorama characterized by stagnating revenues. This situation, coupled with the increase of spending to respond to social demands, and most recently to deal with the coronavirus disease (COVID-19) pandemic, is suspected to have undermined the availability of resources for science and technology budgets.

Table I.1
Latin America and the Caribbean: main instruments used to promote science, technology and innovation

Instruments	Number of countries where they are used
Funding for research and development (R&D)	
Funds for promoting scientific and technological research	17
Teaching incentives for scientific and technological research	6
Equipment and infrastructure improvement funds	6
Funds for the creation of clusters, technology poles and business incubators	5
Personnel training	
Scholarships for undergraduate, postgraduate and postdoctoral studies	16
Programmes to create and support postgraduate studies	8
Support for business innovation	
Funds to promote business innovation and competitiveness	19
Tax credits for R&D	9
Credits for scaling up innovation projects	2
Technical training programmes	11
Support for entrepreneurship	
Entrepreneurship support programmes	9
Promotion of priority areas	
Priority area programmes	12
Sectoral funds	6

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of the Ibero-American Network of Science and Technology Indicators, Políticas CTI: Policies on Science, Technology and Innovation in Ibero-America [online] http://www.politicascti.net/index.php?option=com_zoo&view=category&Itemid=61&lang=en for a total of 21 countries, and information from national sources.

The instruments are organized primarily according to a demand-driven model. Under this model, the most reliable actors for defining research and innovation projects in the areas of science and technology are researchers, and, for innovation, companies. Since these actors face market shortcomings that hinder the development of their projects, the main policy instruments are subsidies granted on the basis of calls for proposals or competitions overseen by specialized public agencies. Within this mechanism, the role of those agencies tends to be limited to the administration of projects and then to their follow-up, essentially from a financial point of view.

C. The need to revamp the strategic role of STI policies

These issues complicate the prospects for advancing science, technology and innovation policies with an economic, social and environmental impact. As noted above, Latin American and Caribbean countries tend to prioritize support for basic research —and, to a lesser extent, for applied research— conducted at universities and research institutes. To this end, governments have relatively mature instruments that channel a significant portion of public research and development spending to these institutions. The flip side to that situation is the relative stagnation of business participation in the funding and pursuit of R&D in the region.

The mix of policy instruments available to support innovation gives the impression that it is incomplete and insufficient to drive significant progress. While some of the factors specific to the economic environment could be hampering business innovation, the absence of supports that are available in many developed countries —such as credits for innovation and public procurement innovations— constrains companies' ability to undertake innovative projects.

The mechanisms that exist for defining the orientation of STI initiatives are detrimental to capacity-building and to addressing important national challenges. In a region with scarce resources, and in an area where scale plays an important role, this strategy of low proactivity in directing resources should at least be reviewed.

This has resulted in a system of STI support that is defined by:

- Projects with weak financing, as a result of which very few advance to the market introduction phase or attain significant socioeconomic impact.
- A wide dispersion of research and innovation projects, which hinders the formation of critical masses of researchers and innovation-intensive companies, limits shared learning and constrains national competitiveness.
- The *de facto* prioritization of short-term projects that do not have the capacity to address certain aspects of national strategic development (a situation that is heightened when governments of different political stripes succeed one another).
- Insufficient attention to research areas that address national challenges, since they are outside the scope of the capacities and priorities of researchers and companies.

The region has an important set of challenges ahead: strengthening public institutions to support STI development, increasing the private sector's commitment to innovation for productivity and competitiveness, improving linkages between STI policies and the region's strategic challenges and promoting regional and international cooperation in the areas of science, technology and innovation.

In recent years, policymakers in Latin America have begun to realize that science, technology and innovation are not separate from other areas of concern to governments and society in general.

Addressing many of the issues that challenge the region's societies, in both the public and private spheres, requires deploying a scientific and technical perspective, since these are increasingly complex problems. This necessarily implies channelling public support for STI —or at least part of it— into areas of knowledge related to the main challenges faced by each country. In particular, public policies can influence the orientation and intensity of private efforts in this area, especially to address challenges when market signals are insufficient and coordination is more challenging.

The current trend is for policies that seek to address and overcome the main economic, social and environmental challenges facing a country by mobilizing productive, technical and knowledge capabilities. It is understood that in addressing those challenges, the country strengthens its national innovation system and its productive capacities. This is a new type of industrial policy, one that no longer focuses on the productive sectors, but on problems and challenges. From that perspective, automatic causality cannot be expected to exist between the development of basic science and its subsequent industrial applications, which may be far apart. The aim is to support research (especially applied research) that allows progress towards resolving a specific challenge.[4]

Among the characteristics of this approach are the interconnections required between different actors, particularly the governmental, academic and business sectors. Innovation becomes a policy area for all areas of government, which demands new institutional arrangements to facilitate coordination and to build capacities for policy formulation and management.

It follows from all the above that the dynamism of technical change processes and the emergence of new national challenges —which have become evident with the eruption of the coronavirus (COVID-19) pandemic and the risks derived from global warming— require that the topics addressed by researchers and innovators in the country are subject to permanent review, and that the effectiveness of the available instruments and the need to establish new ones are permanently monitored.

The next chapter describes some of the sectors or areas in which science, technology and innovation policies have been called upon to contribute in a context of new priorities and regional cooperation and integration.

[4] The scientific or technological responses needed to address these challenges will not necessarily come from R&D initiatives developed in the country itself; in many cases, solutions created in other parts of the world will have to be used.

CHAPTER

II

Guidelines for new times: STI for the development of sectors that drive the economy and society

The 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) highlight the urgent need for progress towards new models of growth and development, with more economically, socially and environmentally sustainable and inclusive consumption and production patterns. The aim is to promote an environmentally friendly economy, based on the use of renewable energies and clean fuels and on production chains that make efficient use of energy, water and other resources, so as to limit waste and greenhouse gas emissions and promote lower consumption of inputs and their greater reuse, recycling and recovery.

As noted by ECLAC (2020), Latin America and the Caribbean must pursue progressive structural change in which the productive structure is reoriented towards more knowledge-intensive sectors, with higher rates of growth in demand and employment. At the same time, the quality and services provided by natural resources and the environment must be preserved. These transformations demand the coordination of technological, industrial, fiscal, financial, environmental, social and regulatory policies. The following sections examine four sectors that meet the above requirements and in which STI policies have an important role to play.

A. Manufacturing industry for the health sector

Manufacturing for the health sector, consisting of the pharmaceutical and medical device industries, plays a crucial role in modern economies. This industry is strategic, in that it provides products and services to improve people's living conditions and health, generates high-quality jobs with solid productive linkages and, since it is highly R&D-intensive and offers important externalities in terms of knowledge, drives technical progress.[5]

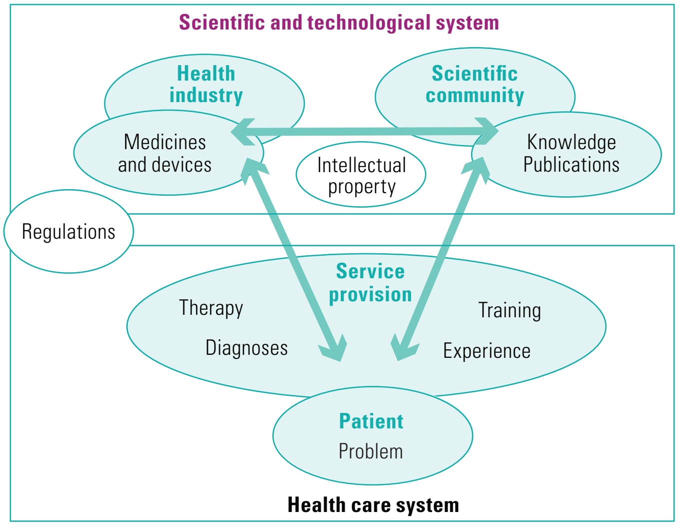
The COVID-19 pandemic and the disruption it wrought in supply chains highlighted the weaknesses of this industry in the region. The critical episodes of shortages —first of medical equipment and then of vaccines— were the result not only of traditional asymmetries in access between developed and developing countries, but also of long-standing structural problems, in particular the inadequate development of regional research and productive capacities.

5 For more details on manufacturing industry for the health sector in the region, see ECLAC (2021a and 2020).

Reducing the region's high dependence on transnational corporations is an essential task, as is strengthening its scientific, technological and productive capabilities to develop more resilient and self-sufficient local industries to deal with future health emergencies.[6] In that context, STI policies have an important role to play.

The development of innovations in the health sector is part of a relatively complex system in which multiple actors interact (see diagram II.1). That system is subject to strict public regulations and highly internationalized.

Diagram II.1
The innovation system in the health sector



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of D. Consoli and A. Mina, "An evolutionary perspective on health innovation systems", *Journal of Evolutionary Economics*, vol. 19, No. 2, 2009.

In the pharmaceutical sector, large transnational companies with parent companies located mainly in the United States, Germany, France, the United Kingdom and Switzerland have remained strongly focused on the introduction of new drugs, especially biopharmaceuticals aimed at highly profitable markets, but they have also diversified their sources for the production of active ingredients in Asian countries, especially China and India, using either their own production facilities or others belonging to third parties. The production of generic products (both in the form of active ingredients and drugs in their final formulations) has become increasingly concentrated in Asian countries, especially India and China.

The Latin American pharmaceutical market is supplied by generic drugs —mostly produced by companies operating locally— as well as by innovative patent-protected drugs that are imported and marketed by transnational companies. Production activities in Latin America tend to be concentrated in the final links of the value chain. They include the formulation, manufacturing, logistics and distribution of products using active ingredients imported mainly from Asia.

The percentage of GDP allocated to health-related R&D in Latin America is much lower than in OECD countries. Although there is no aggregate information for the region, according to the Network of Science and Technology Indicators -Ibero-American and Inter-American- (RICYT), in 2018 the figure for the medical sciences discipline was 0.065% of GDP in Argentina, 0.042% in Chile and 0.063% in Uruguay. Among OECD countries, estimates indicate levels between 0.35% and 0.5% of GDP (OECD, 2018), much higher than those observed in Latin America and the Caribbean.[7]

6 In connection with this, in March 2021, the Government of Mexico, in its capacity as President *pro tempore* of CELAC, requested that ECLAC prepare a health self-sufficiency plan for Latin America and the Caribbean, aimed at strengthening the region's productive and distribution capacities for vaccines and medicines. That plan was presented and approved at the Sixth Summit of Heads of State and Government of CELAC in September 2021 (see ECLAC, 2021a).

7 According to OECD (2018), government budgets for heath-sector R&D in its member countries amounted to 0.1% of GDP in 2014, which must be seen in conjunction with additional amounts of between 0.05% and 0.2% for university research and 0.2% for research conducted by companies. On that basis, it can be estimated that between 0.35% and 0.5% of GDP is invested in health-related R&D.

The scientific and technological system brings together the scientific community and industry. In the Latin American and Caribbean countries, medical sciences account for between 10% and 20% of R&D spending. As a result of the development of a strong research base in the field of health sciences and biotechnology, significant shares of those funds are allocated to projects at universities and technological institutes. The bulk of R&D in the countries of the region tends to take place at universities and, where they exist, at public laboratories.

The industry encompasses companies that research and develop new products and services in the fields of pharmaceuticals and medical devices. This category includes both large companies and science- and technology-based ventures. In general, the region's companies do not participate in the sophisticated innovation dynamics found in developed countries and, increasingly, in countries such as the Republic of Korea and China. Within the region's local pharmaceutical industry, most of the drugs produced are based on generic active ingredients, which results in R&D activities limited to drug formulation processes, medical research and small-scale clinical trials to obtain local-market authorization for those drugs.

Industries producing medical devices in the region also report, at the aggregate level, low levels of innovative effort. This is due to multiple factors: in those countries where they have set up manufacturing plants, the transnational companies have not established R&D units, which tend to remain in their countries of origin (Gereffi, Frederick and Bamber, 2019); in most of the region's countries, domestically owned companies focus on goods with low and medium levels of technological complexity; and this industry's innovation model, which combines numerous technologies and is essentially incremental, does not attract the attention of university researchers.

One very important component of the scientific and technological system relates to the protection of intellectual property over products created in companies and at research institutions. Patenting activity in the health industries in Latin America and the Caribbean is concentrated mainly on inventions filed by international companies, with innovative products of local origin enjoying only a very minor share. In general, this process is limited to reproducing presentations that have already been finalized in other countries of origin. As shown on table II.1, patents granted to Latin Americans in the healthcare sector —including both pharmaceuticals and medical technology— represented only 0.52% of the total number of patents granted worldwide in 2019. While there has been a steady increase in this share in the field of pharmaceutical technologies, it produced no more than 314 granted patents —0.8% of the global total— in 2019.

Table II.1
Latin America and the Caribbean and the world: health patents, 1980–2019
(Totals and percentages)

	1980	1985	1990	1995	2000	2005	2010	2015	2019
Pharmaceutical patents									
World total	7 374	9 982	9 408	12 397	14 748	21 455	29 038	38 830	39 245
Latin America and the Caribbean	34	43	21	37	66	125	174	304	314
Region's share of the total *(Percentages)*	0.46	0.43	0.22	0.30	0.45	0.58	0.60	0.78	0.80
Patents for medical technology									
World total	7 177	10 678	12 865	15 206	18 592	24 573	36 499	56 486	72 152
Latin America and the Caribbean	56	33	64	39	73	247	295	213	266
Region's share of the total *(Percentages)*	0.78	0.31	0.50	0.26	0.39	1.01	0.81	0.38	0.37
Health patents									
World total	14 551	20 660	22 273	27 603	33 340	46 028	65 537	95 316	111 397
Latin America and the Caribbean	90	76	85	76	139	372	469	517	580
Region's share of the total *(Percentages)*	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 information from the Ibero-American Network of Science and Technology Indicators, and World Intellectual Property Organization (WIPO), "Intellectual property statistics" [online] https://www.wipo.int/ipstats/en/index.html.

This low level of patenting is a direct result of the lack of linkages between the region's research centres and companies in the sector. This has to do, first, with the limited incentives for patenting that have historically existed at universities and technological institutes and, second, with the fact that the pharmaceutical companies producing in the region have increasingly specialized in generic products with expired patents. These companies generally do not have the capacity to undertake the kind of efforts needed to introduce innovative products on a global scale.[8]

Some countries have centres with research capabilities located away from their universities. With public base funding, these have been able to undertake research projects with execution schedules and scales of resources that have brought them closer to production. Examples include public laboratories with long traditions and production capacities, such as the Butantan Institute and the Oswaldo Cruz Foundation (FIOCRUZ) in Brazil, the Leloir Institute Foundation (FIL) and the Dr. Carlos G. Malbrán National Administration of Laboratories and Health Institutes (ANLIS) in Argentina and the Pasteur Institute in Uruguay, and private foundations such as the Ciencia & Vida Foundation in Chile.

These entities have been instrumental in introducing products such as vaccines, incubating start-ups and capacity-building, providing an important source of expertise in situations such as the one that arose with the COVID-19 pandemic.

In the health care system, new products are made available to medical centres for prescription to patients (in the case of drugs) or for clinical use (in the case of medical devices). Hospitals and physicians play an important role in the innovation system by providing the manufacturers with feedback about the real-world performance of new technological products introduced into their routine clinical work.

The health innovation system may be affected by the way in which new health technologies are acquired and, in particular, by the public procurement system. If the State is an eager adopter of health innovations, this will have a positive effect on the innovation system.

Regulatory systems are responsible for ensuring that drugs and medical devices produced or sold in a country meet minimum requirements for safety, quality and efficacy. Health regulatory capacities are not uniform across the region's countries. According to an assessment by the Pan American Health Organization (PAHO, 2020), out of 33 member countries in the region, six have fully fledged national regulatory authorities, 13 have the necessary legal bases and organizational structures to implement a comprehensive regulatory system, seven have some of the necessary legal bases and organizational structures, and another seven have no such capacities. There is also a positive correlation between country size and regulatory capacity. An effort to accelerate regulatory convergence would be an essential step in strengthening the innovation systems of the region's health care industries.

The challenge that the arrival of COVID-19 posed for the countries of Latin America and the Caribbean triggered a re-evaluation of the strategic options that most of them began to pursue in the mid-1990s. Since then, there had been a tendency to rely on external suppliers as the preferred source for the procurement of drugs and medical devices. In the wake of the pandemic, a new priority of strengthening national and regional health industry capacities can be clearly seen.

Progress toward the goal of self-sufficiency in the health sector requires major efforts at the national and regional levels. This is related to multiple features of these industries: (i) the central role of STI in the industry's performance and the differences that exist in the capabilities available in this area between the region's countries and more advanced nations, (ii) the cumulative nature of the generation of scientific, technological and productive knowledge, which requires coherent, long-term policy initiatives, (iii) the wide range of public and private actors and knowledge institutions with different objectives involved, which demands permanent efforts to keep them aligned, and (iv) the existence of considerable economies of scale in production, which underscores the importance of efforts to expand access to regional markets in order to be competitive with large global producers.

8 According to Schlander and others (2021), the average research and development cost associated with the launch of a new drug ranges from US$ 161 million to US$ 4.54 billion.

In order to progress with the creation of health industry innovation systems that can contribute to countries' resilience in the face of situations such as the one caused by the COVID-19 pandemic, a combination of policy efforts at the national level and collaborative initiatives among the region's countries is required.

The necessary steps at the national level include: (i) increasing public contributions to R&D activities, (ii) increasing the scale and duration of projects, (iii) strengthening public, academic and private centres of excellence, (iv) building connections among players in the health industry innovation system, and (v) improving the patenting, registration and approval processes for innovative health industry products and processes.

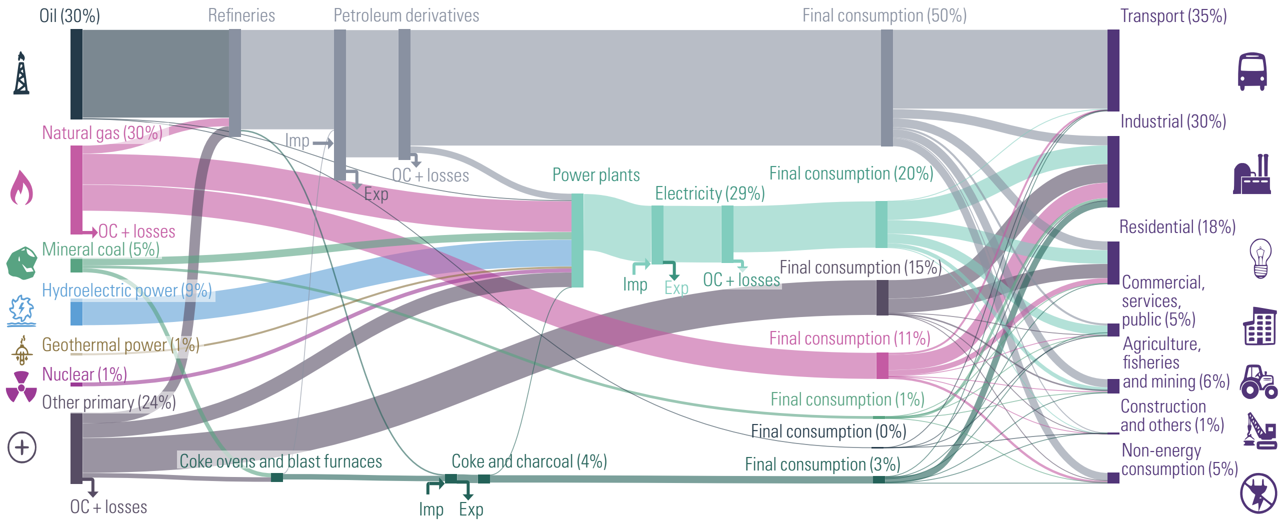
At the same time, in order to strengthen regional collaboration, the following measures are needed: (i) development of innovation programmes aimed at solving regional problems and challenges, to be implemented by transnational regional consortiums, (ii) promotion of integration processes in the education sector and exchanges of students and researchers, (iii) expansion and formalization of the mutual recognition of registered drugs, (iv) complementing the countries' installed capacity with a regional platform for clinical trials, to consolidate mutually recognized regulatory standards, (v) regulation of procurement strategies through the creation of a supplier database that ensures compliance with quality and safety standards, timeliness of supplies and correct pricing, and (vi) strengthened regional mechanisms for joint purchases of medicines and medical devices during health emergencies.

B. Energy transition

Combating climate change requires moving towards a low-carbon energy supply mix and low-carbon forms of consumption through the increasing adoption of energy from renewable and clean sources. This process has to take place at a time of strong growth in the region's energy supply, which has increased 2.4 times over the past 50 years, with a slight decrease in the share of energy within regional GDP. Within primary energy production, renewables have grown slightly faster, to account for 33% of the total in 2020. This trend was historically led by hydropower, but wind, solar, biomass and, more recently, geothermal energy are growing rapidly.

The region's energy mix is dominated by fossil fuels, which accounted for 65% of the primary energy supply in 2020. In sectoral terms, transport is the region's largest final consumer of energy (35%) —which is supplied almost exclusively by fossil fuels— followed by industry (30%) and residential use (18%) (see diagram II.2).

Diagram II.2
Latin America and the Caribbean: summarized energy balance, 2020
(Percentages)



Source: Latin American Energy Organization (OLADE), *Panorama energético de América Latina y el Caribe 2021*, Quito, 2022, p. 51.
Note: Flows coming from the left indicate the total supply of each of the energy sources.
The "other primary" category includes biogas, bio-waste, sugarcane products, firewood, solar and wind.
Imp: imports; Exp: exports; OC: energy sector's own consumption.

At the same time, a trend currently exists towards the electrification of the transport, residential and industrial sectors. Meeting the region's potential demand for electrification is, however, an enormous challenge. Studies by ECLAC (2020) have concluded that the regional electricity sector will have to practically double its output to meet projected demand and, at the same time, substantial investments in infrastructure and distribution networks, which are largely obsolete and inefficient, will be required.

Renewable energies, particularly wind and solar energy, are already cost-competitive with fossil fuels, especially gas and coal.[9] This is a necessary but not sufficient condition for accelerating the energy transition, which is essential in the context of the climate crisis and the need to build a new economy based on renewable energies in the region's countries.

Finding a clean and sustainable manner to meet the growing demand for electricity —the result of economic development and the need to increase electrification— requires replacing fossil fuels with renewable energies, promoting and strengthening regional electricity integration initiatives and focusing efforts on making the management of national electricity grids more flexible. Along with increasing the efficiency of energy use at the sectoral level, the generation and use of renewable energies such as solar, wind, geothermal and bioenergy must be expanded. That type of energy encourages "environmental sustainability and energy sovereignty and reduces external vulnerability (especially for countries that are net importers of fossil fuels). It also creates opportunities for universalization of electricity access (because these types of energy are modular and decentralized), technological learning and economic growth (because of the investments involved)" (ECLAC, 2020, p. 133).

According to ECLAC (2020), the region's energy transition must help resolve structural problems and shortcomings through a productive transformation that adds value, innovation and technology to make energy consumption more efficient and to reduce greenhouse gas emissions through decreasing reliance on hydrocarbons. The energy transition is a process of building an ecosystem of regulation, governance and instruments aimed at the simultaneous pursuit of five goals: (i) increasing the share of renewable energies in the energy mix, (ii) providing the population with universal access to electrification and reducing energy poverty, (iii) pursuing greater energy efficiency in all productive sectors, (iv) achieving greater complementarity and integration among the region's energy systems, and (v) ensuring the security of the region's energy and its resilience to external shocks.

Of course, in order to make the energy transition a reality, countries must be equipped with a battery of instruments —including regulations, tax incentives and investment financing mechanisms— and the promotion of technological innovation is one more component within this set. The innovation and development of renewable energy encompasses not only its generation (e.g. hydrolysers for green hydrogen) but also its distribution and, more importantly, its storage in batteries, a task for which the region is generously endowed with critical minerals such as lithium and copper.

At the same time, evaluations should be conducted to identify the optimal combination for each territory or subnational entity (such as cities or remote, isolated rural localities). For example, wind and solar energy have the lowest relative cost, but due to their variability during the day and the seasons of the year, they require greater investments in storage and have higher operating costs. Geothermal energies are relatively more expensive but their output is much more stable, while biofuels are produced more stably and are storable, but they require careful management of their emissions, the sustainable cultivation of the raw materials (biomass) they use and careful consideration of their opportunity costs vis-à-vis food production. All the alternatives require taking on board the needs of local communities, which are vital to achieving a comprehensive energy transition.

In terms of the technological R&D requirements in the field of renewable energies, consideration should be given to the technologies described below.[10]

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9 Global figures depend on the scale of production, the technology used and the time of launch. Therefore, domestic prices for energy from different sources may vary from one country to the next.

10 This section is based on Leañez (2022), which was produced at the request of ECLAC.

Photovoltaic solar energy

The main technologies required to generate electricity from photovoltaic solar cells are silicon crystal (c-is), cadmium telluride (CdTe), copper indium gallium selenide cells (CIGS cells) and amorphous silicon (a-Si). Currently, silicon crystal modules are the market's dominant photovoltaic technology, accounting for 95% of the expansion of global solar PV capacity in 2020 (IEA, 2020). However, trends going forward remain uncertain. The World Bank estimates a breakdown of 50% for silicon crystal with the remaining technologies sharing the other half in equal proportions, but it also offers alternative scenarios to 2050 in which each of the technologies could attain market shares of 50% (Hund and others, 2020).

Wind power

Currently, most wind power generation facilities are located onshore. Offshore generators account for less than 0.5% of the world's installed wind power capacity. The main technologies —both those currently in use and those forecast for the long term— are summarized in table II.2.

Table II.2
Wind power generation technologies

Generator type	Acronym	Turbine type	Deployment
Direct drive	DD-HTS	High-temperature superconductors (HTS)	Offshore
Direct drive	DD-EESG	Electrically excited synchronous generator (EESG)	Onshore
Gearbox	GB-EESG	Electrically excited synchronous generator (EESG)	Onshore
Direct drive	DD-PMSG	Permanent magnet synchronous generator (PMSG)	Onshore and offshore
Gearbox	GB-PMSG	Permanent magnet synchronous generator (PMSG)	Onshore and offshore
Gearbox	GB-DFIG	Double-fed induction generator (DFIG)	Onshore and offshore
Gearbox	GB-SCIG	Squirrel cage induction generator (SCIG) Without full onshore converter	Onshore
Gearbox	GB-SCIG	Squirrel cage induction generator (SCIG) With full offshore converter	Offshore
Gearbox	GB-WRIG	Wound rotor induction generator (WRIG) onshore	Onshore

Source: F. Leañez, "Intensidad de materiales en la transición energética de América Latina: estimaciones sobre la base de un escenario de integración energética de América del Sur", *Project Documents* (LC/TS.2022/46), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022, p. 17.

GB-DFIG technology dominates more than 70% of the market. The DD-PMSG technology's share has doubled in the last 10 years, to reach 20% in 2020. DD-PMSG technologies are expected to command 40% of the onshore technologies market by 2040 (IEA, 2020, cited in Leañez, 2022, p. 18). Permanent magnet generators account for 76% of the offshore technology market.

Batteries

The development of battery technologies facilitates the storage of renewable energies and allows flexibility in their use. Three kinds exist: lead-acid, lithium-ion[11] and other chemical storage options, such as nickel metal hydride, redox flow, sodium sulfur and other compositions currently under development.

Hund and others (2020) have calculated estimates of battery market shares to 2050. For electric vehicles, they project that lithium-ion will command a 100% share and that the use of lead-acid batteries will decrease linearly to zero by 2030. In industrial applications, they project a share of between 2.5% and 5% for lead-acid technologies, between 70% and 84% for lithium-ion, between 2.8% and 3.7% for redox flux, and between 9.8% and 25% for other technologies. For distributed generation (DG), they estimate that lead-acid batteries will hold a 33% share, lithium-ion 33%, and other technologies 33%.

11 Lithium has become a key resource in the global value chain for electric batteries and electromobility strategies. The importance of lithium over the past decade has led to a discussion in the region's countries —especially in the so-called "lithium triangle" (Argentina, Chile, and the Plurinational State of Bolivia)— on the productive capacity and sustainability of lithium use, the distribution of revenues and the contribution of mining activities to productive diversification through the development of suppliers, technologies, innovation and research. See, for example, Jiménez and Sáez (2022).

Geothermal energy

Geothermal energy may have the greatest potential of all renewable energy sources as deep-drilling technologies evolve. Drilling (for both exploration and exploitation) accounts for most of the construction costs of a geothermal power plant.

Biomass

The carbohydrates that plants accumulate from capturing solar energy can be used as fuel by drying and burning that material to release thermal energy, or they can be fermented to produce olefins (methane and ethane) and alcohols (methanol and ethanol). Those processes, however, require efficiency improvements.

Concentrated solar power

The two main technologies used to collect concentrated solar power (CSP) are parabolic trough collectors and central tower systems. Parabolic trough collectors accounted for more than 80% of the growth in concentrated solar power capacity in 2010, but their share has been steadily declining since then: central tower systems, which have higher efficiency and storage capacity, have been dominating the market instead. Central towers accounted for about 60% of concentrated solar power capacity growth in 2020, and their share is expected to rise to 75% by 2024 (IEA, 2020, cited in Leañez, 2022, p. 21).

Moreover, in addition to the various technologies described above, there is growing agreement that the development of green hydrogen (the production and consumption of which does not generate greenhouse gases) could play a key role in meeting decarbonization targets. Given that Latin America and the Caribbean has some of the world's most abundant and competitive renewable energy resources —including hydropower, solar and wind energy— sustainable and renewable (green) carbon-free hydrogen could be one of the drivers of the next phase of the region's transition to clean energy.

Policies should be implemented to promote the green hydrogen industry as a driver of sustainable reindustrialization, in order to form an industrial cluster with export potential distributed throughout Latin America and the Caribbean. One of the challenges is due to the fact that the region still lacks the right technologies —specifically, electrolysis machines— for producing green hydrogen, so the imperative is to build capacities for deploying an industry that can operate within the region, with trained experts to oversee and maintain its activities.

C. Electromobility

Oil has traditionally been the predominant source of energy for transport, with which it is responsible for around 25% of global greenhouse gas emissions (UNEP, 2021). Therefore, the sector's transition towards the use of non-polluting energy sources —electric power in particular— promises to make a substantial contribution to combating climate change and environmental pollution.

Technological progress with vehicle electrification and batteries has been the basis for new products and production processes, which, combined with increasingly stringent environmental standards and strategic government actions, are driving important changes in the automotive sector. Between 2017 and 2021, the share of electric vehicles in light vehicle sales (passenger cars, vans, sport utility vehicles and pickup trucks) increased from 1.3% to 8.3%, for a total of 16.5 million (IEA, 2022). Sales of these vehicles could reach an estimated total of 20.6 million by 2025, accounting for 23% of global automobile sales (BNEF, 2022). In general, the sector's robust growth has been supported by strict carbon dioxide (CO2) emission standards and the existence of purchase subsidies and tax breaks in major markets.

Both manufacturing and purchases of electric vehicles (EVs) are heavily concentrated in China, Europe and the United States. The major global manufacturers are supplying the region's local markets with imports. However, charging infrastructure shortcomings and low consumer awareness and confidence mean that EVs still account for a low share of total automobile sales, although the proportion is growing rapidly. The automotive industry installed in Latin America is beginning —albeit slowly— to align itself with this transition in production.

The global trend towards electrification has also made major inroads in the heavy-duty vehicle sector, mainly as regards buses. Electric buses are rapidly moving towards technological maturity, particularly as regards their batteries, which increases range and reduces manufacturing costs. There are currently around 670,000 electric buses and 66,000 electric trucks in circulation worldwide, representing 4% and 0.1% of the global fleets (IEA, 2022). This evolution has been accompanied by numerous commitments from national and subnational governments setting specific dates and deadlines in the transition to electromobility in public transport.

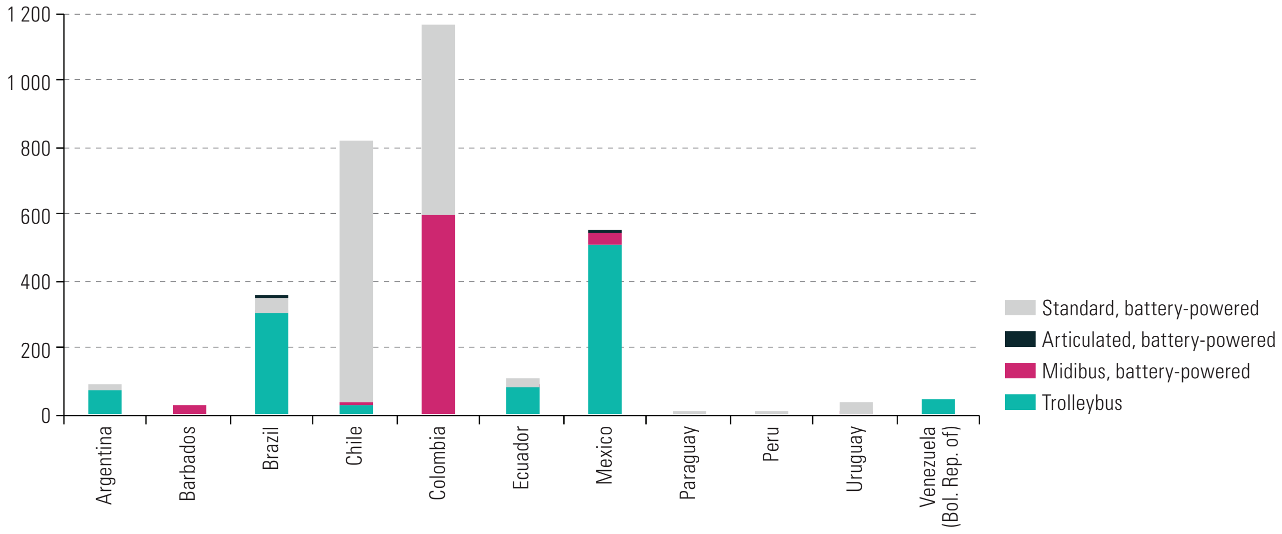
The electric bus market is also strongly concentrated in China, the result of an ambitious strategy to reduce environmental pollution in the country's major cities, the development of renewed public transport systems and the strengthening of local technological and productive capacities. Currently, about 90% of the electric buses in operation in the world are deployed in Chinese cities.

Analysts expect the electric bus market to grow rapidly over the coming years. Between 2022 and 2027, annual sales of electric buses worldwide could rise from 112,041 to 671,285 units (Sustainable Bus, 2022). Although China will continue to maintain its leadership, significant growth is expected in Europe and, most particularly, in the United States. In addition, some developing countries will gradually begin to participate more actively in this market, especially India and various Latin American economies.

In Latin America, the adoption of stricter environmental standards and regulations aimed at reducing greenhouse gas emissions has led to a degree of progress with electromobility. Some countries, including Chile, Colombia and Costa Rica, have established targets for electrifying their public transport fleets. Among the region's countries, instruments that promote the acquisition, use and deployment of electric buses have been at the forefront. Most of these initiatives, however, fail to prioritize the procurement of locally produced buses.

In April 2022, a total of 3,209 electric public transport vehicles were on the road in Latin America and the Caribbean, representing less than 4% of the total bus fleet of Latin America's main cities. Colombia, with 1,165 units, currently leads the adoption of electric buses, most notably in the city of Bogotá; it is followed by Chile with 819, Mexico with 556 and Brazil with 351 (see figure II.1).

Figure II.1
Latin America and the Caribbean (11 countries): electric buses in use, by type, April 2022
(Vehicles)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of E-BUS RADAR, "Latin America", April 2022 [online] https://www.ebusradar.org/en/ [accessed on 23 June 2022].

In most cases, the first steps towards electrification are being taken by importing vehicles and much of the key support infrastructure. Chinese manufacturers are the main suppliers of electric buses in Latin America, accounting for more than 70% of purchases.

Despite the region's incipient increase in demand for electric buses and favourable outlook for the coming years, the regional supply is not keeping pace. In order to break the inertia that characterizes several of the agents involved with Latin America's adoption of electric buses, innovative business models have been implemented that separate ownership from operation and that offer a range of benefits including subsidies and financing mechanisms. This has allowed the entry of new players historically not involved in the automotive sector, such as energy companies, which are essential for the deployment of recharging infrastructure.

The current juncture —marked by the need to address dangers relating to climate change and to accelerate the transformation of the automotive sector— offers a window of opportunity for developing new productive capacities in Latin America, particularly for the manufacture of electric buses.

Policies to support the creation and expansion of this industry target both demand and supply considerations. The industry's development in the region requires the creation of a market that can guarantee predictable demand and an adequate scale of production. This requires progress with the planning of a gradual, progressive and time-bound transition to electromobility. On the supply side, mechanisms must be created, particularly funding instruments, to support investment and the creation of local production capacities in regional companies. The preparation of a strategy to electrify production, coordinated and agreed upon by public and private stakeholders, is key to attracting and mobilizing investment.

Against that backdrop, and particularly in an area where uncertainties still persist regarding future technological developments, coupled with limited specific capacities at the regional level, STI policies have an important role to play.

In particular, the technological differences between traditional and electric buses must be taken into account. The central component of electric buses is their internal battery system, which is recharged externally through a connection to the mains supply.

Electric buses comprise seven subsystems (De los Santos, 2022):

(i) Chassis: a platform consisting of two longitudinal members and transverse structures that support the vehicle's mechanical components.

(ii) Powertrain: comprises those elements that enable the vehicle to move, including its electric motor, transmission, axles and tyres. In electrically driven units, this does not include the battery modules, which make up another subsystem.

(iii) Steering and control: allows the vehicle's trajectory to be determined, by means of steering wheel movements that actuate the steering rod, in addition to other components related to the driving process.

(iv) Electric subsystem: covers the battery modules, upper connections for fast charging and a connector for recharging energy from the mains. Depending on the configuration of this subsystem, the bus will have different speed, start-up and range capacities, along with other characteristics. The configuration of battery modules can vary in terms of their chemical components (lithium ion, i.e. lithium titanium (LTO), nickel cobalt manganese (NMC) or lithium ferrophosphate (LFP) (Sustainable Bus, 2021)), their capacity (generally between 150 and 450 kWh (MJB & A, 2020)) and the number of batteries installed, among other features.

(v) Body frame and bodywork: the external metal parts that form the vehicle's skeleton, including upper, lower and side structures. This frame is installed on the chassis. The elements of the bodywork determine the vehicle's particular configuration, including the sides, doors, windows, lights and so on.

(vi) Interior: composed of all the internal elements that make up the vehicle's user space, including the seats and other functional and comfort elements.

(vii) Auxiliary: additional supporting subsystems, including the air conditioning system, power steering, air compressor, 24V auxiliary connection and other components directly or indirectly related to the vehicle's driving (Halmeaho and others, 2015).

The most significant differences between the subsystems of electric and conventional buses is the powertrain and electrical charging subsystems (see table II.3). Internal combustion vehicles do not have electrical charging subsystems. In addition, electric powertrain buses require various adjustments to the technologies that make up the chassis and the steering and control subsystems. Finally, the fact that the bus is electric is irrelevant to some subsystems, such as the bodywork, body structures, and interior, so they remain comparable.

Table II.3
Comparison between conventional and electric bus subsystems

Subsystem	Elements of a conventional bus powertrain	Elements of an electric bus powertrain	Difference
Powertrain and charging	Internal combustion engine, transmission, fuel tank and after-treatment system	Electric motor, battery modules, fast-charge connectors and recharging socket	High
Electrical components	Low-voltage systems	High-voltage systems	High
Steering and control	Hydraulic	Electric	High
Brakes, axles, suspension and differential	Standard	Regenerative brakes and suspension adapted to the increased battery weight	High
Chassis	Standard	Adapted for installation of the battery set	Low
Interior	Standard	Standard	No change
Frame and bodywork	Standard	Standard	Low
Instrument panel	Standard (analogue and/or digital)	Some minor changes for electric charging	Low

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of S. Galarza, "Sesión 2: Introducción a los autobuses eléctricos y sus beneficios", paper presented at Ciclo de Jornadas Virtuales de Fortalecimiento de Capacidades para la Transición hacia el Transporte Público Eléctrico, 19 November 2020 [online] https://movelatam.org/wp-content/uploads/2020/12/Presentacion-Sesion-2.pdf.

Note: The nomenclature of the systems (or subsystems) used on this table is taken from the source, so there may be differences from the terminology used elsewhere in this document.

In bus manufacturing, different business models address the vertical integration of processes in the same plant. In Latin America, a model with low vertical integration is common, focusing on the manufacture and assembly of the body frame and bodywork, to offer the market customized solutions that respond to specific customer needs as well as more economical purchasing options. These integration companies deliver the final product to the customer and also add other essential components such as seats, the driver's cabin, passenger facilities, paint, livery and so on.

One alternative and complementary model is to retrofit conventional vehicles by replacing the internal combustion engine with an electric powertrain. Conventional vehicles chosen for retrofitting are generally already in operation, and the aim is to convert them while their remaining working life can justify that investment. Retrofitting has a long history in Latin America, but it has been limited to academic projects, pilot business initiatives and small-scale mechanical workshops. In recent years, the lower cost compared to the purchase of electric vehicles has meant that retrofitting has become increasingly important. However, the lack of regulation is one of the main barriers to the mass uptake of technological options of this kind.[12]

The development and expansion of key EV technologies requires public-private cooperation and coordination to explore innovative cost-reduction solutions. For example, the creation of industrial R&D laboratories would make it possible to bring together universities, governments and companies around research projects dedicated to motorization and battery technologies. In addition, strategic areas and topics must be defined to guide the promotion of R&D through different instruments. The creation of specific R&D support programmes in strategic areas for the development of the production chain could help develop local capabilities and contribute to the repositioning of the industry.

The progressive electrification of bus production is a challenge with technological, economic, environmental and social dimensions and, as such, must be accompanied by a broad set of complementary measures. First, efforts must be made to promote the development of renewable energies and sustainable production processes,

[12] To address that problem, ECLAC has proposed a regulatory framework to accelerate investment in electromobility through the retrofitting of vehicles that use fossil fuels (ECLAC, 2021b).

including the introduction of mechanisms for battery disposal at the end of their working lives in line with the principles of the circular economy. Progress must also be made with recharging infrastructure to enable the efficient operation of these new city buses. The creation of new business models that mobilize investments at the scale required to meet the transport system requirements of the region's cities is fundamental. In addition, the continuous training of qualified workers must be ensured to guarantee the operation and maintenance of electric buses in the different contexts of Latin American cities.

D. Eco-innovation and sustainable production

In Latin America and the Caribbean, the transition to more sustainable production systems is a complicated matter. First, the region faces the challenge of accelerating its growth and reducing its productivity and income gaps with the developed world, while at the same time improving the quality of life of its citizens by ensuring access to basic goods and services. Second, its productive structure based on static comparative advantages skews economic activities towards the exploitation of natural resources and sectors that make intensive use of energy (especially fossil fuels), water and raw materials. These challenges are compounded by a high degree of business heterogeneity. The region has a large number of smaller, low-productivity companies that face difficulties in accessing technology and financing to respond to stricter environmental regulations, change their production and marketing processes and invest in equipment and technology.

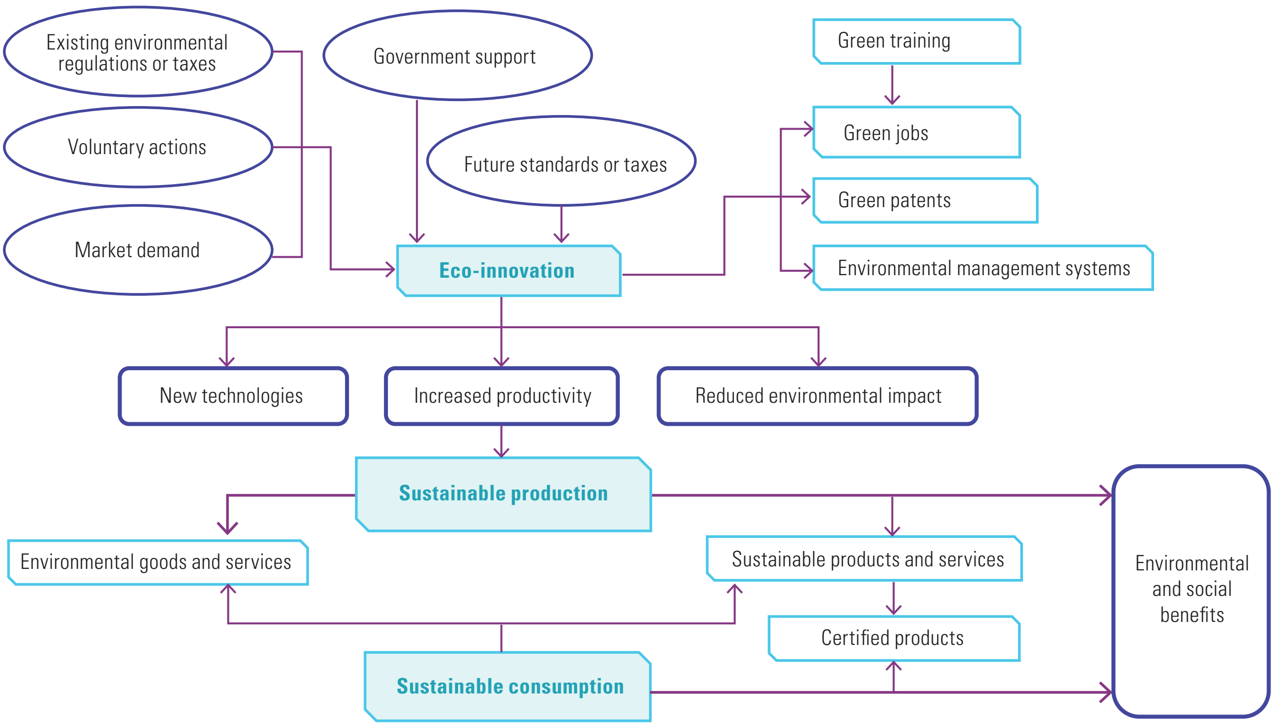
The business world's innovation strategies now include environmental themes. With this, new ways of doing business are promoted and the need to improve resource productivity is emphasized. Growing demands related to compliance with increasingly stringent environmental regulations and the importance of reducing costs have also driven efforts to increase energy efficiency, reduce the volumes of waste generated, promote recycling and optimize packaging.

Eco-innovation is the search for more sustainable production models. This term refers to the capacity of businesses to improve efficiency in the use of natural resources and to reduce pollution by adopting new and more environmentally friendly processes, products and organizational and commercial practices.

Several factors influence eco-innovation, in the areas of expected impact (productivity, innovation, lower environmental impact) and in its relationship with other concepts, such as sustainable production and consumption (see diagram II.3). The introduction of new technologies can favour the development of new activities for the production of environmental goods and services and for increased employment ("green jobs") linked to these activities. This goal requires industrial, technological, innovation and training policies that help the region move towards sustainable consumption and production models.

Latin America and the Caribbean report poor levels of investment in research and development (R&D), especially in comparison with the dynamics seen in other more advanced and emerging regions. Analyses reveal that public R&D efforts with environmental objectives in the region vary greatly from one country to the next. In some cases, such as Costa Rica and Mexico, the shares are equal to or higher than those of more advanced countries, such as Spain or the United States. The region's countries for which information is available indicate that they spend, on average, 5.22% of their R&D budget on environmental oversight and care. However, if total R&D expenditure on environmental objectives is examined terms of GDP, it can be seen that the more advanced countries allocate a higher proportion of GDP to environmental R&D (see table II.4).

Diagram II.3
Determinants of eco-innovation and its relationship with sustainable production and consumption



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

Table II.4
Latin America and the Caribbean (8 countries), Spain and the United States, public spending on environment-oriented research and development (R&D),[a] most recent year with information available
(Percentages of total R&D spending and percentages of GDP)

Country	*(Percentage of total R&D spending)*	*(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 information from the Ibero-American Network of Science and Technology Indicators, and the Organisation for Economic Co-operation and Development (OECD), OECD.Stat [online database] http://stats.oecd.org/.

Note: Data for Argentina, Costa Rica, El Salvador, Mexico and Trinidad and Tobago are from 2016; for Chile, from 2017; for Spain, Guatemala and Paraguay, from 2019; and for the United States, from 2018. In Spain, spending disaggregated by socioeconomic objective does not include the business sector. Since 2004, the series has been revised by the Ministry of Science and Innovation, using the new classification of the Nomenclature for the analysis and comparison of scientific programmes and budgets (NABS 2007). The United States changed its classification by socioeconomic objectives in 2006. In El Salvador, the data reported as spending on science and technology covers expenditure by the higher education and government sectors. In Guatemala, the information reported covers spending by the government and higher education sectors. In Mexico, the figures reported for spending on science and technology activities covers only federal spending on science and technology.

[a] Refers to environmental care and stewardship.

An analysis of worldwide patent patterns reveals major efforts directed towards environmental stewardship (renewable energies, electric and hybrid vehicles, energy efficiency in buildings, water and waste treatment and so on), but this is concentrated in the most advanced economies, such as the United States, Japan and the European countries. For example, between 2010 and 2018, the United States filed an average of 50 times more environmental patents per capita than the whole of Latin America and the Caribbean. However, the region managed to double its patent numbers in this area between the periods 2000–2009 and 2010–2018. At the same time, the proportion of environmental patents in the total in Latin America and the Caribbean is similar to the world average: only one point below that of the OECD countries, and higher than that of the United States and China (see table II.5).

Table II.5
Total patents and environmental patents per million inhabitants, 2000–2009 and 2010–2018
(Numbers)

Region or country	Average 2000–2009			Average 2010–2018		
	Total patents	Environmental patents	Environmental patents as a proportion of the total *(Percentages)*	Total patents	Environmental patents	Environmental patents as a proportion of the total *(Percentages)*
World	89.2	7.0	7.8	91.9	9.9	10.7
Organisation for Economic Co-operation and Development (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), PATSTAT [online database] https://www.epo.org/searching-for-patents/business/patstat.html.

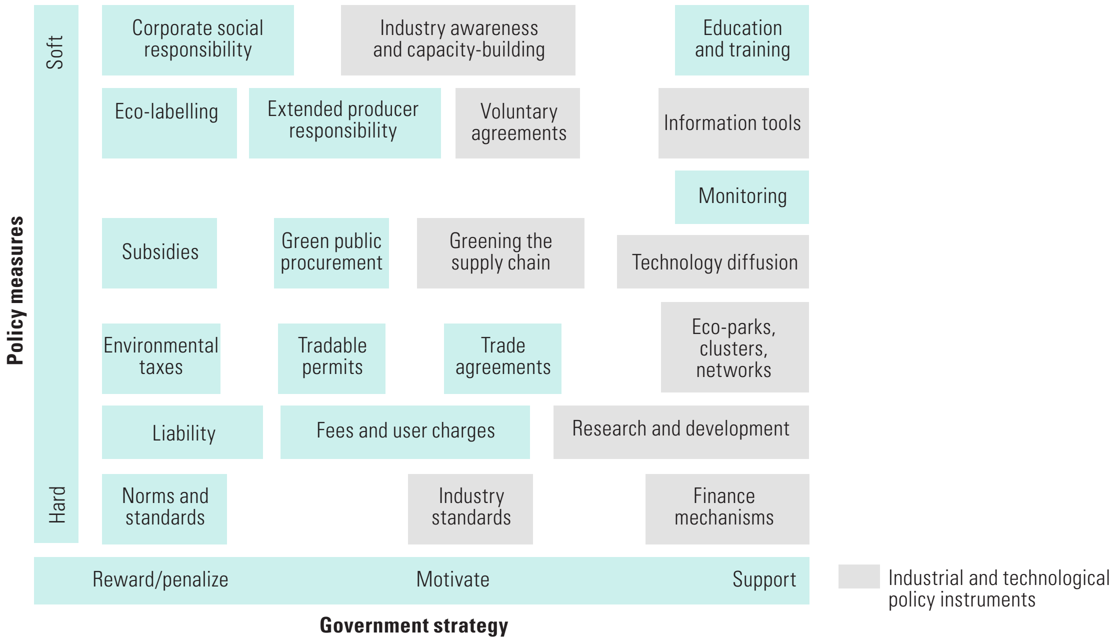
Between 2000 and 2020, the number of ISO 14001:2015 certifications (environmental management systems) in the world rose by 16% annually and to reach an annual total of 348,473 certifications, concentrated in Asia and the Pacific (60%) and Europe (30%). In 2020, those two regions respectively registered 89 and 123 certifications per million inhabitants. Over the same period, the number of certifications per year in Latin America and the Caribbean rose at an annual rate of 18%, to reach 11,878 in the year (3% of the total), with 18 certifications per million inhabitants.

One of the major barriers to revealing more about eco-innovation processes in the region is the lack of data and statistics on companies' adoption of environmental practices. Despite that situation, there are a number of specific initiatives aimed at encouraging the collection of data on the subject. One of these was the incorporation of specific questions on eco-innovation in the Survey of Innovation (PINTEC) conducted by the Brazilian Institute of Geography and Statistics (IBGE).

A range of factors exist that drive changes in production and consumption patterns towards more sustainable models. Growing environmental awareness is motivating companies to adopt strategies to reduce their environmental impact, especially in response to consumer demand in more developed countries for products and services that incorporate elements of environmental responsibility. At the same time, local communities are also bringing pressure to bear to ensure that the natural ecosystems where some companies operate are respected. These trends, coupled with stricter environmental regulations and standards, are driving a variety of business and industry strategies.

Governments can pursue a wide set of measures to promote sustainable production. STI policies are present and interact within that policy mix. Diagram II.4 shows the different policy instruments that can come into play in a sustainable production strategy. Interventions may be mandatory or voluntary. Measures that involve incentives more than penalties are shown at the top left. The lower left corner shows those that are mandatory, relating to environmental taxes and norms and standards. Instruments that are linked to technology and innovation policies are included among the voluntary support instruments, such as training, technology dissemination, access to funding, standard setting and information tools.

Diagram II.4
Sustainable production policy matrix



Source: United Nations Industrial Development Organization (UNIDO), *UNIDO Green Industry: Policies for Supporting Green Industry*, Vienna, 2011, p. 14.

While meeting the objectives of sustainable production requires an integrated approach to policy formulation, in many cases environmental issues are the responsibility of a single institution. This is the case in most of the countries, where there is a specific entity in charge of the topic, either at the ministerial level, within a ministry or within the framework of a public service with environmental responsibilities. In some countries, in addition to a governmental agency in charge of the topic, committees or commissions with representatives from different government sectors have been established to take charge of the formulation and implementation of national public policies for sustainable consumption and production. In order to respond to these demands and move towards a greener growth model, an integrated and cross-cutting framework for action must be defined, coupled with joint work and dialogue between the government, the private sector and civil society (Rovira, Patiño and Schaper, 2017).

Through public intervention in STI, operational instruments have evolved to include technology funds, sectoral funds, venture capital incentives, cooperation initiatives between universities and companies, sustainable public procurement and networks. The environmental dimension unquestionably adds a new factor of complexity to those initiatives. Meeting the challenge of sustainable production requires applying, with continuity and coherence, technological and industrial policies that motivate the coordination of institutions in different economic, productive and environmental spheres. Also necessary are agendas that set specific short-, medium- and long-term objectives and goals for the environmental practices of companies.

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Science, technology and innovation (STI) policies have a central role to play: not only in building national research and development capacities, but also in solving national problems and challenges within the framework of countries' development policies.

Given the region's structural weaknesses, scarce resources and the need for scale to achieve results, the resources allocated to support science, technology and innovation –or at least part of them– must be channelled into areas of knowledge related to the main challenges the countries face.

STI must contribute to the development of sectors and activities that drive the economy and society. Four of them are discussed in this publication: manufacturing industry for the health sector, energy transition, electromobility, and eco-innovation and sustainable production.

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