Science, technology and innovation in the digital economy

The state of the art in Latin America and the Caribbean

UNITED NATIONS
ECLAC

Second session
of the Conference
on Science, Innovation
and ICTs of ECLAC

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This document was prepared by the Economic Commission for Latin America and the Caribbean (ECLAC) for the second session of the Conference on Science, Innovation and Information and Communications Technologies of ECLAC, held in San José on 12 and 13 September 2016.

The document was prepared by the Innovation and New Technologies Unit of the Division of Production, Productivity and Management of ECLAC. Mario Castillo and Sebastián Rovira were responsible for its coordination. It was drafted by Wilson Peres, Sebastián Rovira, Gabriel Porcile, Adrián Rodríguez, Francine Brossard, Mônica Rodrigues, Alejandro Patiño and Patricio Valderrama.

Support for the preparation of this document was received under the project "Innovations for a sustainable structural change" as part of the joint programme between ECLAC and the German Agency for International Cooperation (GIZ) "Structural change for a sustainable and inclusive development in Latin America and the Caribbean".

Distr.: General • LC/G.2685(CCITIC.2/3) • November 2016

S.16-00832

Contents

Foreword

We live in an age shaped by processes that are changing the global economy, repositioning countries and shifting the balance of power between economic blocs and between developed and emerging economies.

Major transformations at the international level include the rise of China; mega-agreements in trade, investment and intellectual property; demographic change and migration; consensus on the environmental costs of the growth model; and the gathering speed of the technological revolution. Hence the need to progress towards a sustainable and more equal development model.

The new Sustainable Development Goals and the 2030 Agenda for Sustainable Development present the region with additional challenges in maintaining consumption and production levels that are compatible with the environment. For this reason, an environmental big push —driving investment patterns that support innovation and structural change while decoupling economic growth from carbon emissions— is key to pursuing new paths to development.[1]

The countries of Latin America and the Caribbean have reached an economic tipping point. In an uncertain global landscape with a clear recessionary bias since the 2008 financial crisis, growth in production, international trade and job creation has slumped. And yet, the challenges that our countries face are not economic alone. The progress made in poverty reduction and social inclusion in Latin America and the Caribbean has stalled over the past three years. In 2014, 167 million people (28% of the entire population) were living below the poverty line, a figure that already showed a loss of momentum compared with earlier years. The extreme poverty index that year stood at 12%, slightly up on 2013. Slow economic growth in 2015 and 2016 has likely worsened these indicators, and the outlook for 2017 is not much brighter.

The global economy is undergoing a deep crisis with no clear end in sight, and the countries of the region, like others, have adopted expansionary measures on the fiscal and monetary fronts to mitigate its effects and hasten the economic recovery. These measures are necessary and urgent. But the region's long-run issues and ongoing development problems must not be overlooked. Rapid technological change and new technology paradigms should have a stronger impact on economies in the post-crisis world. The region must prepare to take up this challenge by strengthening its science, technology and innovation policies.

A country's ability to participate in global trade and growth depends on its technological, social and organizational innovation capacity. The hallmark of the new knowledge economy is the centrality of innovation to competitiveness and to the international division of work. However, it is not only a question of how much a country innovates. The direction and quality of innovation also matter, especially in terms of their effects on environmental sustainability and social inclusion. This is particularly relevant in the Latin America and the Caribbean, the world's most unequal region.

Innovation leads to the creation of new products, processes, sectors and activities, and drives structural change which in turn encourages more innovation. The result is a virtuous cycle of growth that reflects an increasing appreciation for knowledge-based value added. History shows us that this process is neither automatic nor spontaneous: internal capacity, institutions and policies, all supporting innovation, are crucial.

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[1] See ECLAC, *Horizons 2030: Equality at the Centre of Sustainable Development* (LC/G.2660/ Rev.1), Santiago, 2016.

Technology trajectories are inseparable from developments in employment and production, and it is essential to determine which types of innovation are best suited to achieving the three goals of economic growth, social inclusion and environmental sustainability. Although innovation, technological progress and structural change have been present in ECLAC thinking since its inception, the understanding of these themes has shifted over time. In the 1950s, technological progress was associated with industrialization, in the expectation that this would boost productivity and reduce external vulnerability. Since the early 1960s, ECLAC has been increasingly concerned with improving income distribution, on the understanding that spreading technological progress should create good-quality jobs and diminish structural heterogeneity. Our vision today includes a new and critical dimension: structural change must be environmentally sustainable in order to drive development. Innovation should not only narrow the gap with the developed world and promote equity, but also reduce the environmental costs of growth.

Each country's positioning in the global economy depends on its ability to absorb knowledge and move closer to the technology frontier. Where do Latin America and the Caribbean stand in this respect? Unfortunately, despite the progress made, indicators of innovation efforts and access to technology —which are among the themes addressed in this document— are not promising. Our countries are also poorly positioned to absorb and participate in knowledge creation in new technology paradigms, particularly in the general-purpose technologies that spread through and influence the entire production system. ICT-related technologies and their applications in industry, agriculture and services are especially crucial in this regard.

These are some of the challenges that our region faces, and for which we aim to help craft solutions by identifying public policies that can pave the way to more inclusive and sustainable development.

In offering this document to the governments and people of Latin America and the Caribbean, ECLAC endeavours to provide an overview of the main themes related to science, technology and innovation, against the backdrop of the progress of the industrial Internet and advanced agriculture and manufacturing. We hope it will help to further understanding of one of the greatest present and near-future challenges facing the region.

Alicia Bárcena

Executive Secretary
Economic Commission for Latin America
and the Caribbean (ECLAC)

I. A depleted growth model: recessionary bias, inequality and environmental crisis

A. The world is searching for a sustainable pattern of development

- The global economy is facing major challenges that call for a change in the prevailing development pattern. Awareness of the environmental, economic and social limits of the prevailing development pattern has grown considerably in recent years.
- The international community has mobilized to put forward a response. The 2030 Agenda for Sustainable Development and the Sustainable Development Goals represent an emerging consensus in the search for a new development paradigm.
- The 2030 Agenda represents a major step forward politically, as the outcome of a wide-ranging multilateral debate involving governments and social stakeholders. Furthermore, it restores the principle of shared but differentiated responsibilities among the countries in the environmental, economic and social spheres; and its broad range of topics implies a conceptual framework that recognizes the complexity of the situation.
- Equality and environmental sustainability are the Agenda's main pillars. Fulfilling it depends on initiatives such as the promotion of full employment with productivity and quality, dimensions in which innovation and technology have fundamental roles to play.

■ **Diagram I.1** ■
Sustainable Development Goals

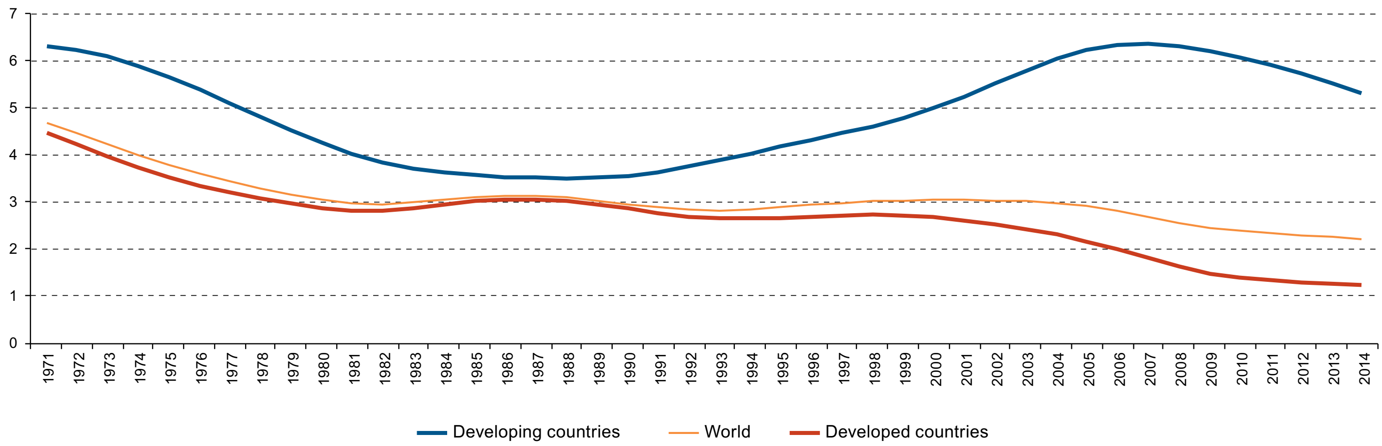
169 targets-231 indicators

Source: United Nations [online] http://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible.

B. The global economy's recessionary bias is deepening

- The recovery of trade and economic growth since the 2008 crisis has been slow and unstable; and GDP growth rates around the world have been systematically lower than in the 1990s or in 2000-2007.
- The sluggish growth of aggregate demand has undermined investment owing to its impact on expected returns. Dwindling investment has impaired productivity growth, since the latest technological innovations are already embedded in the most recent capital stock. Alongside the declining trends in economic growth and investment, productivity growth has tended to slow or even stall, particularly in the developed world.
- On a positive note, the performance of the developing economies improved over this period; although this largely reflected the performance of China, while results in Latin America and the Caribbean were weaker.
- The weakness of the recovery in the global economy is being compounded by worries about the possibility of a new crisis. First, many economies have high debt levels and financial systems that are decoupled from the real economy. Second, in the absence of coordinated expansion among the economies, countries with trade deficits try to correct them by reducing imports, because they do not see good prospects for expanding their exports. This in turn further weakens global aggregate demand.

■ **Figure I.1** ■
Global GDP growth, 1971-2014
(Percentages)



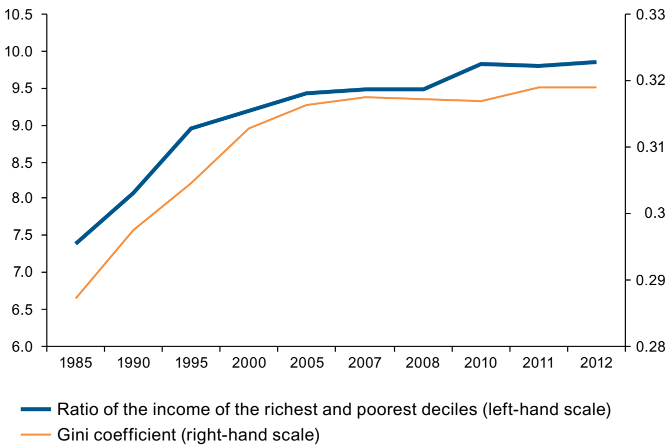
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data provided by the World Bank.

C. Inequality is increasing in the world's leading economies

- Rising inequality is a key factor in the social and political tensions seen in recent years, even in the more developed economies. By curbing aggregate demand growth and increasing household debt levels, income inequality holds back economic recovery and increases its instability.
- The economies of the Organization for Economic Cooperation and Development (OECD) have become more unequal since the 1980s. Figure I.2 shows the increase in the Gini coefficient up to the middle of the 2000 decade, together with the rising income share received by the wealthiest decile compared to that of the poorest. In 1985, the average income in the wealthiest decile was seven times the average in the poorest decile, but by 2013 this multiple had risen to 10 times. While both indicators were relatively stable between 2004 and 2008, they have risen again since the crisis. Another indicator of greater inequality in the most advanced economies, the share of wages in GDP, fell from 63% in 1960-1980 to 56% in 2012.
- In the countries of Latin America and the Caribbean the dynamic has been different, with inequality and poverty levels declining substantially over the last decade. More recently, however, poverty indicators have started to rise, which is worrying for a developing region that suffers from egregious social disparities.

■ **Figure I.2** ■

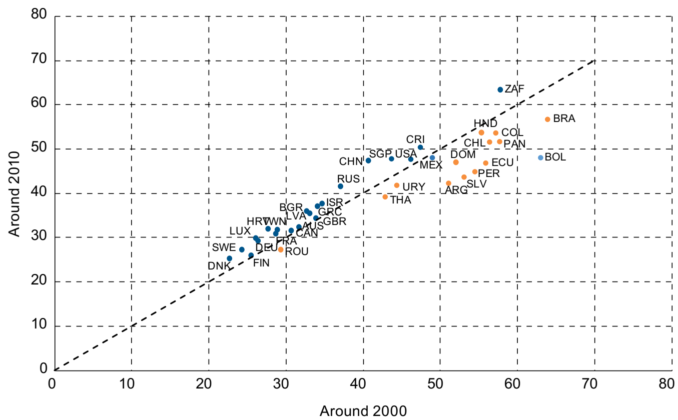
OECD member countries: Gini coefficient and ratio of average incomes of the richest and poorest deciles, 1985-2012



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), *In It Together: Why Less Inequality Benefits All*, Paris, 2015.

■ **Figure I.3** ■

Latin America (14 countries) and other selected countries: Gini coefficient, around 2000 and 2010



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, World Development Indicators, 2015 and All the Ginis Dataset, Organization for Economic Cooperation and Development (OECD) and Luxembourg Income Study Database (LIS).

D. The current development model entails growing risks for the environment

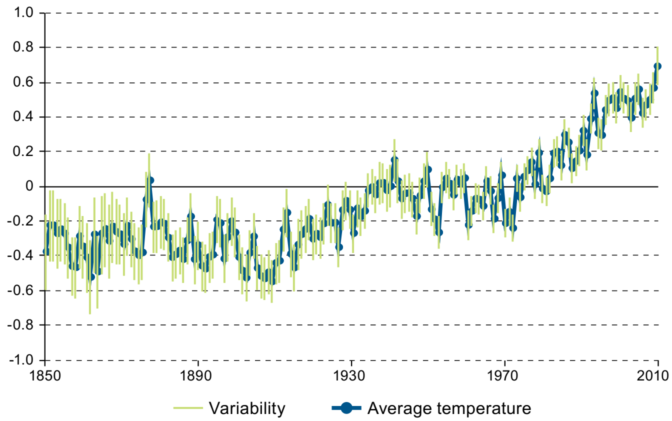
- There is consensus among the scientific community that the current model could lead to environmental catastrophe in the long term, with potential to compromise the development possibilities of future generations. Furthermore, given the non-linear dynamics of environmental systems, the situation could already be close to a point of no return, whereupon environmental damage would become irreversible. Nicholas Stern (2006) has referred to pollution and climate change as "the greatest market failure the world has ever seen".
- Figure I.4 shows indicators that reflect the environmental dynamic: the behaviour of land and ocean surface temperatures, and the extent of summer sea ice in the Arctic.
- Land and ocean surface temperatures have been rising steadily since the early twentieth century, but this process has become faster since the 1960s. This goes hand-in-hand with a shrinking of the Arctic ice cap and rising sea levels that put coastal cities in greater danger.

■ **Figure I.4** ■

Environmental impact of the prevailing growth pattern

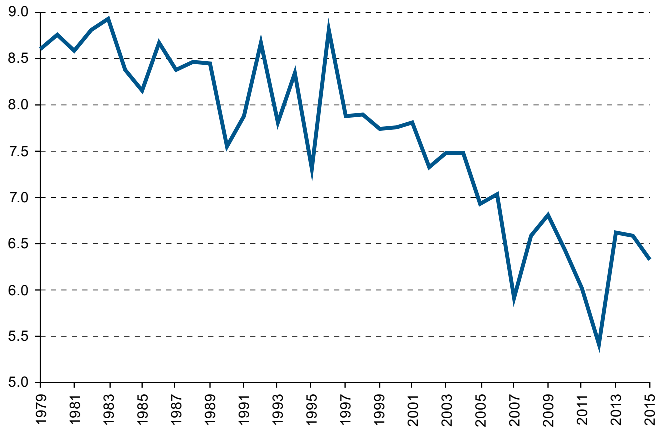
A. Anomalies in the combined land and ocean surface temperatures, 1850-2015[a]

(degrees Celsius)



B. Summer Arctic sea ice extent, 1978-2015[b]

(millions of square kilometres)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, World Development Indicators and International Union for Conservation of Nature (IUCN).

[a] Data on temperature correspond to the difference between the world average of the combined land and ocean surface temperature, expressed in annual averages from 1850 to 2015, and the average for the period 1961-1990. Data are from the HadCRUT4 database of the Met Office Hadley Centre in the United Kingdom.

[b] Data on Arctic sea ice refer to the average for July, August and September and come from the National Snow and Ice Data Center (NSIDC).

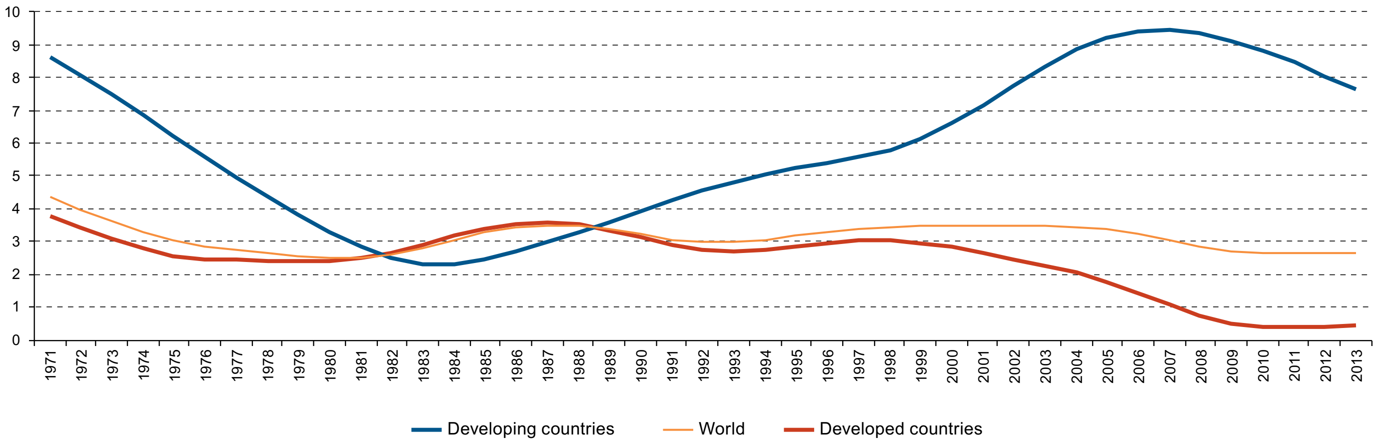
E. A new development pattern requires new global public goods

- The 17 Sustainable Development Goals and their 169 targets are built around job creation, equality in the broad sense and environmental stewardship. It is an extensive and ambitious set of objectives that converge in the demand for global public goods by civil society, governments and international organizations. Such goods are necessary for moving towards a new pattern of development. One of them is international coordination to promote global environmental Keynesianism (ECLAC, 2016).
- In view of the obstacles to a sustained recovery of growth, expansionary fiscal policies are needed to foster investment and boost the growth rate. As monetary policy and quantitative easing have exhausted their capacity to stimulate the economy, it is time for fiscal policy to play a larger role. Given the risk of secular stagnation and the slump in global investment, a fiscal policy based on public investment is the key to restoring growth prospects.
- Figure I.5 shows the fall in the global investment rate. As in the case of economic growth, the developing countries outperformed the developed ones, although this result is again heavily influenced by the performance of China's economy.

Figure I.5

Trend growth rate of gross fixed capital formation, 1971-2013

(Percentages)



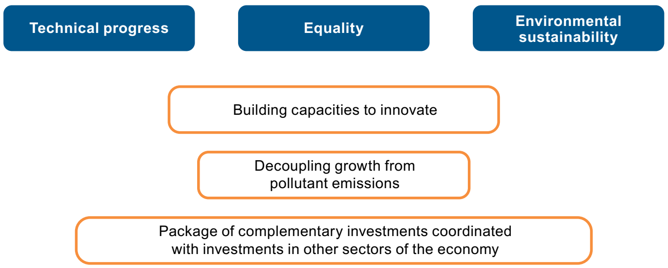
Source: Comisión Económica para América Latina y el Caribe (CEPAL), sobre la base de Banco Mundial, World Development Indicators, 2015.

F. The regional development strategy requires an environmental big push based on the dissemination of technology

- The investment effort based on greater fiscal activism should be targeted to changing energy patterns and transport systems to make them environmentally sustainable. It is not enough to apply a Keynesian fiscal policy globally; while this would help to restore growth in the short term, it would not be environmentally sustainable if it continued along the previous development path. The investment push must lay the foundations (in terms of infrastructure, consumption and transport) to enable the economies to move onto low-carbon paths. The twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21), held in 2015, gave very clear signs that a new institutional framework is being built which will be capable of nurturing the change towards sustainable patterns of production and consumption.
- Global environmental Keynesianism must be accompanied by an environmental big push, particularly in the developing economies, which need require articulated packages of investments to overcome the coordination problems that hold back industrial diversification and technology absorption if they are to escape from the low growth/low productivity trap.
- An effort of this type is not merely a need, but also an opportunity for technical progress in the region's economies. Technical progress in digital technologies, nanotechnology and bioeconomics would make it possible to combine a low-carbon growth path with the development of sectors intensive in knowledge use and dissemination. The transformation of production and consumption patterns will be viable only if the change helps to close gaps in income and technological capacities between the advanced and the developing economies.

■ Diagram I.2 ■

The environmental big push



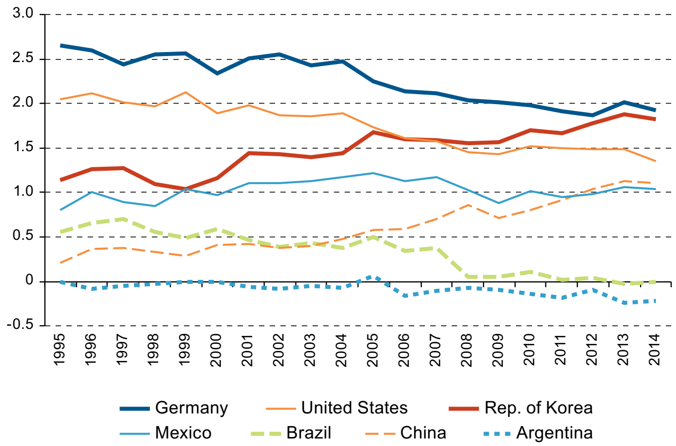
Source: Economic Commission for Latin America and the Caribbean (ECLAC).

G. The region must move towards more complex innovation-based production structures

- Shifting towards more technology-intensive sectors is the key to long-term growth. One indicator of this process is the complexity of a country's economic structure. Figure I.6 shows the 1995-2014 trend of the Hidalgo-Hausmann index of economic complexity, which combines indicators of the diversification and sophistication of a country's capacities. An economy is more complex if it has a diversified production structure that includes sectors or activities that exist in few countries. Such activities are not widespread because they require sophisticated technological capacities that are beyond the reach of many economies.
- While the complexity of Mexico's production structure changed little between 1995 and 2014, those of Argentina and Brazil declined. The same also happened in Germany and the United States, although these latter countries started from very high initial levels.
- By contrast, China and the Republic of Korea significantly increased the complexity of their production structures, through industrial policy strategies of targeting investment efforts on new technology sectors and more knowledge-intensive areas, such as the digital economy, which has enabled them to significantly narrow the productivity gap with the most advanced economies.

■ **Figure I.6** ■

Selected countries: Hidalgo-Hausmann index of economic complexity, 1995-2014



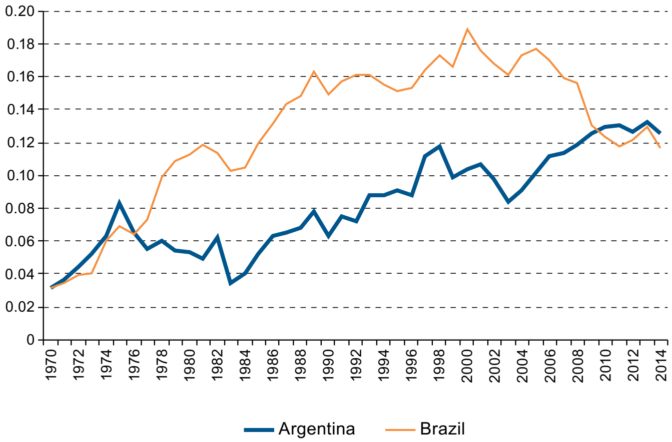
Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Horizons 2030: Equality at the Centre of Sustainable Development* (LC/G.2660/ Rev.1), Santiago, 2016.

H. Complex structures are associated with greater investment in research and development (R&D) and patenting

- Other indicators that directly capture the scale of technology efforts (such as R&D spending as a percentage of GDP) and their results (such as the share of total global patents) add weight to that conclusion. Figures I.7 and I.8 show the trend of the CEPALITEC indicator —which combines data on patents (normalized) per capita, with data on high-technology exports— in Argentina, Brazil, China and the Republic of Korea.
- In Argentina and Brazil, structural change and the process of increasing the technology content of production structures have been slow, compared to the rapid progress observed in the Asian economies, until the last few years when the pace has slackened.
- Conversely, the two Asian countries, which started from situations similar to those of the region at the start of the 1970s, substantially and steadily improved their innovative structures and dynamics.
- The region's lag in terms of production structure and technological capabilities is particularly serious given its negative impact on productivity and long-term growth potential.

Figure I.7

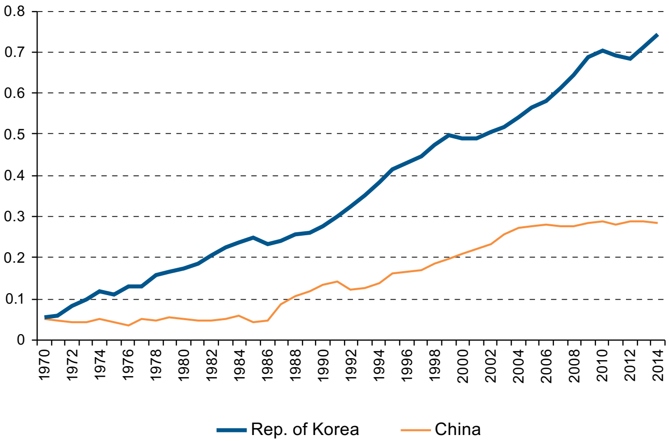
Argentina and Brazil: indicator of technological intensity (CEPALITEC), 1970-2014[a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC).
[a] CEPALITEC is calculated as the average of normalized patents per million inhabitants and the volume of medium- and high-technology exports.

Figure I.8

China and the Republic of Korea: indicator of technological intensity (CEPALITEC), 1970-2014[a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC).
[a] CEPALITEC is calculated as the average of normalized patents per million inhabitants and the volume of medium- and high-technology exports.

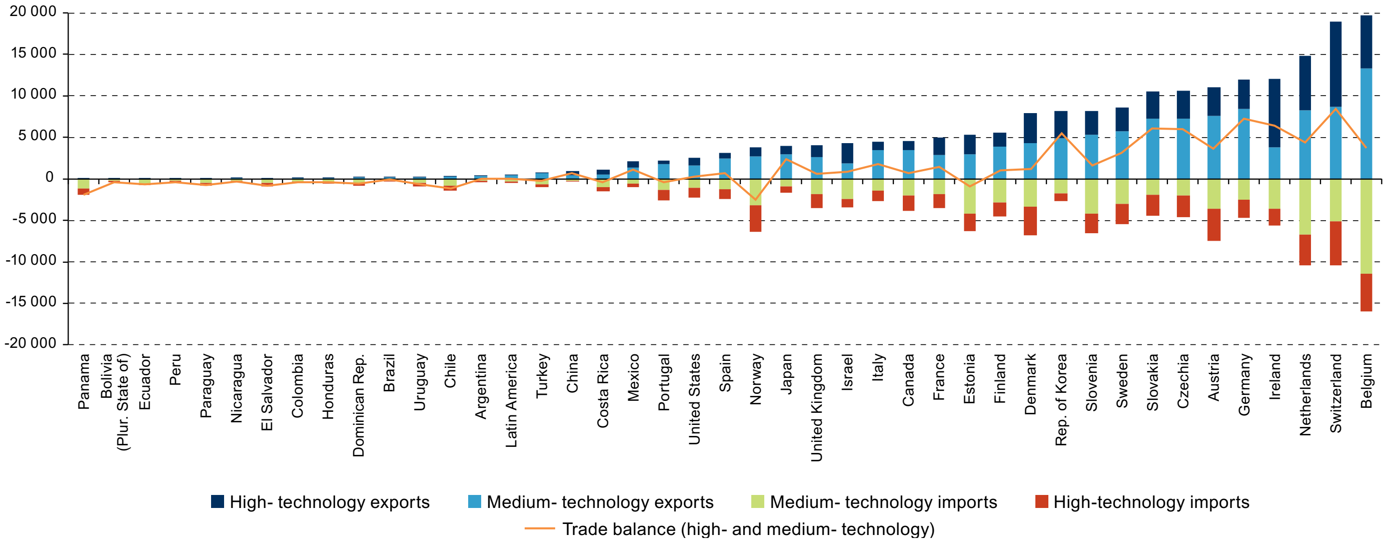
I. Lack of structural complexity is associated with poorly diversified exports

- Countries that base their competitiveness on exports of high-tech products require workers with advanced skills and high levels of investment in R&D, while maintaining close links between the production system and science and technology. High-tech sectors are less exposed to the entry of competitors, so they earn higher revenues. As a result, nearly all developed countries are exporters of technologically advanced products.
- Countries that export large volumes of high-technology products will require more scientists and skilled technicians. Sectors that export technologically advanced goods will find it hard to survive without human resources capable of developing the corresponding products. Yet, the workers of an economy have no incentive to specialize and invest in becoming advanced human capital without a market that demands those skills. This dilemma reduces the chances of countries that do not export technology-intensive goods being able to do so in the future, unless they plan an adequate technological and industrial development strategy.
- Figure I.9 shows per capita exports and imports of medium- and high-technology goods in 2014, at current prices. The developed countries export about US$ 2,000 per capita of this type of goods, whereas in Latin America only Mexico attains that level. Costa Rica exports about US$ 1,000 per inhabitant and levels in other countries are around US$ 500. In addition, the technologically advanced countries maintain trade surpluses in high- and medium-technology goods, which does not happen in the region's economies.

Figure I.9

Per capita exports and imports of medium- and high-technology products, 2014

(Dollars at current prices)



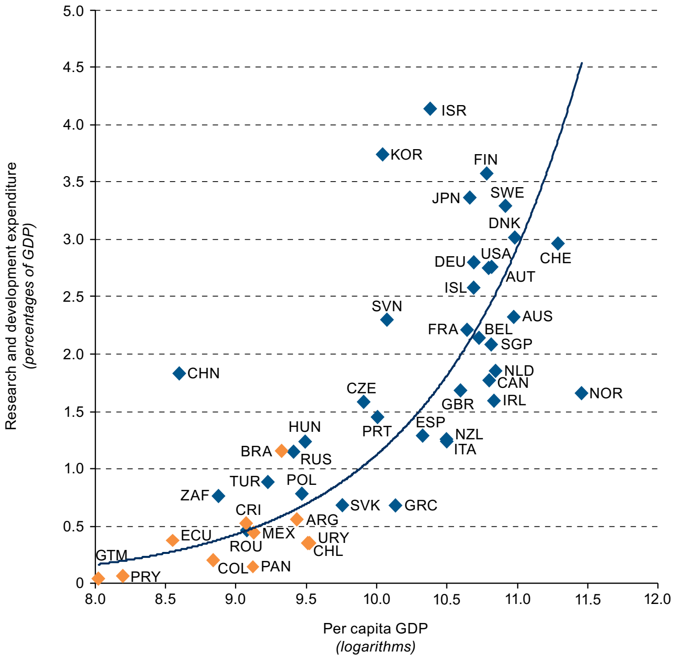
Source: Economic Commission for Latin America and the Caribbean (ECLAC), Graphic System for International Trade Data (SIGCI) and on the basis of data provided by the World Bank.

J. Per capita income is positively and significantly correlated with investment in innovation

- As countries develop new products, processes and ways of organizing production, their economic and social structures change both quantitatively and qualitatively. This is reflected in an increase in their per capita income and resources for R&D, which creates a virtuous circle of innovation and economic growth.
- All sustained economic growth processes have occurred in contexts where public and private institutions shaped the development paths and fostered the creation of scientific and technological capacities. Nonetheless, the precise relation between innovation and development, and the formulation of policies to stimulate knowledge accumulation and dissemination are the subject of debate.
- Investment in R&D is one of the main indicators of the technology and innovation effort. Worldwide, there is a very high correlation between such investment and an economy's per capita income. The link is not decisive or one-way, but also depends on variables such as human resource capabilities, the efficiency of institutions (research centres and universities) and the pattern of industrial specialization.
- In figure I.10, all countries close to the technology frontier appear in the upper right-hand quadrant. By contrast, the Latin American countries occupy the lower left-hand quadrant, because their per capita GDPs are among the lowest of the countries considered, and their R&D expenditure does not exceed 0.5% of GDP, except in the case of Brazil, which invests around 1.2% of its GDP in this area.

Figure I.10

Selected countries: per capita GDP and research and development expenditure, average 2009-2013



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data provided by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the World Bank.

II. Innovation and knowledge generation: global trends and regional challenges

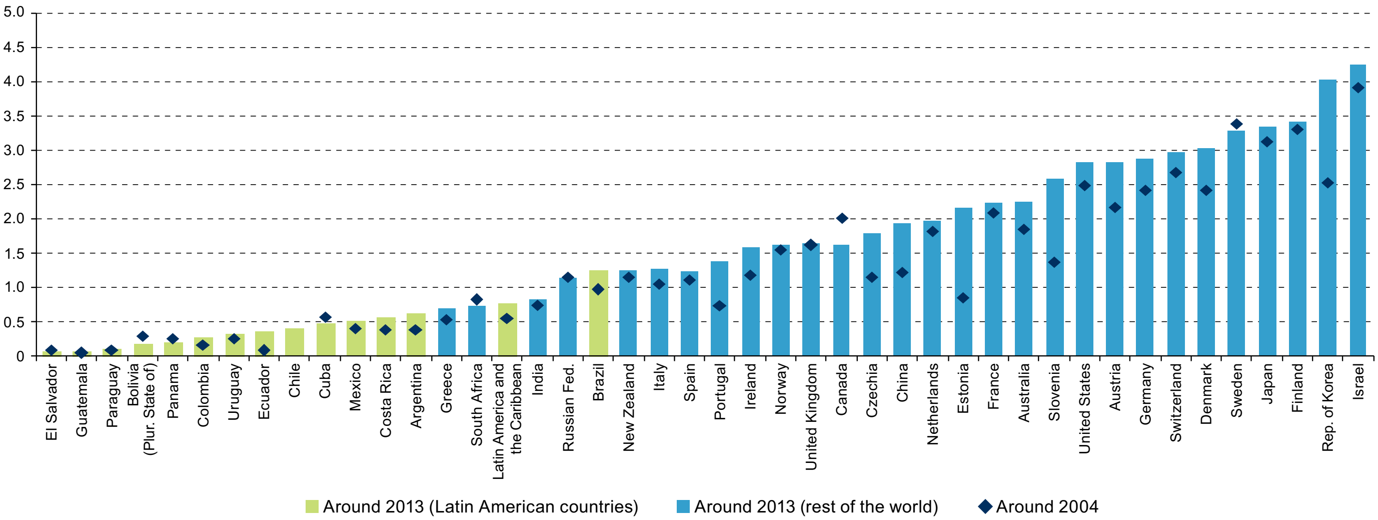
A. The region does minimal research and development (R&D)

- In Figure II.1, the countries can be divided into five groups by their R&D investment intensity. The first group, with R&D spending above 2% of GDP, consists of developed countries, with Israel, the Republic of Korea, Japan and Finland as the leading investors.
- The second group (R&D between 1% and 2% of GDP) includes economies such as Spain and Norway. Brazil (1.2%) is the only country in the region that belongs to this group.
- The third group (R&D between 0.5% and 1%) consists of countries such as Greece and South Africa, along with Argentina, Costa Rica and Mexico from Latin America.
- The fourth group (between 0.2% and 0.5%) comprises Colombia, Chile, Cuba, Ecuador and Uruguay. Lastly, the fifth group (less than 0.2%) includes El Salvador, Guatemala, Panama, Paraguay and the Plurinational State of Bolivia.
- This information confirms the Latin American countries' low propensity to invest in R&D, except for Argentina, Brazil, Costa Rica and Mexico. However, even these countries do not attain the level of innovation seen in the technologically advanced countries. The data also clearly reveal the high degree of heterogeneity among the region's economies, which will be reflected in most of the variables related to innovation and technological capacities analysed in this report.

Figure II.1

Investment in research and development (R&D), around 2013 and 2004

(Percentages of GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from United Nations Educational, Scientific and Cultural Organization (UNESCO) and Ibero-American Network of Science and Technology Indicators (RICYT).

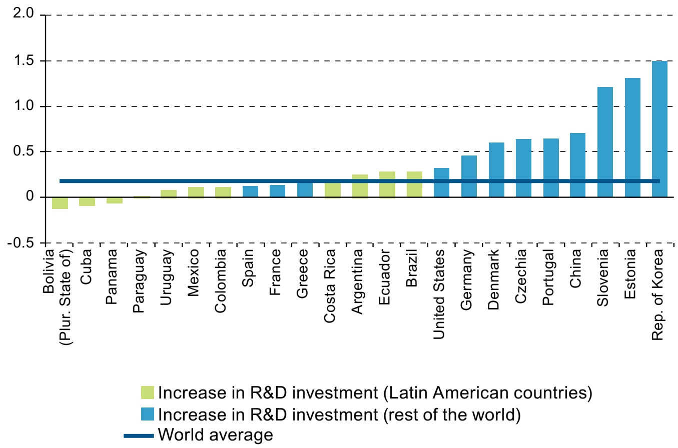
B. Insufficient progress since 2004

- The dynamic of R&D investment among Latin American countries between 2004 and 2013 shows the region stalling relative to other emerging countries, which have expanded their technological and knowledge frontiers —even relative to technologically mature and advanced countries.
- Figure II.2 displays five groups of countries. In the first, which contains Estonia, the Republic of Korea and Slovenia, R&D expenditure grew by over one percentage point of GDP between 2004 and 2013.
- The second group (with increases of between 0.5 and 1 percentage points) includes China, the Czech Republic, Denmark and Portugal.
- The third group, which includes several countries from the region (such as Argentina, Brazil and Ecuador) along with a number of developed countries (for example Germany and United States) increased their investment by more than the global average of 0.18 percentage points, but without exceeding 0.5 points.
- The fourth group includes some of the countries in which the variable in question grew by less than 0.2 percentage points, such as Colombia, Costa Rica, Mexico and Uruguay, as well as several mature economies that have been slow-growing in this area over the last few years (for example France and Spain).
- Lastly, there are countries in which R&D investment retreated between 2004 in 2013, such as Cuba, Panama and the Plurinational State of Bolivia.

■ **Figure II.2** ■

Rate of growth of the share of GDP devoted to research and development (R&D), 2004-2013

(Percentage points)



Source: Comisión Económica para América Latina y el Caribe (CEPAL), sobre la base de información de la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (UNESCO) y la Red de Indicadores de Ciencia y Tecnología Iberoamericana e Interamericana (RICYT).

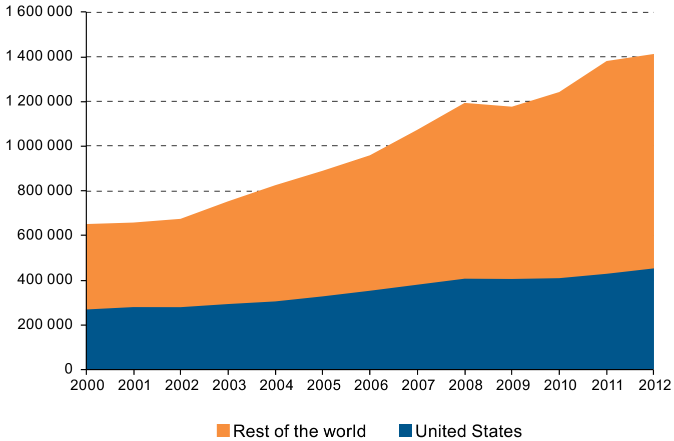
C. The region accounts for 2.8% of global expenditure on R&D, one third of its share of world population

- In the last few decades, global investment in R&D rose sharply, far outpacing economic growth. Despite stalling during the crisis that erupted in 2008, it has regained its pace thanks to the momentum generated in the emerging economies.
- Although the United States and Japan remain the leading players (accounting for 33% and 15%, respectively, of global R&D expenditure in 2012), their hegemony has started to come under threat from the progress made by China, which grew its share from 1.6% in 2000 to 11.8% in 2012.
- China has adopted a growth strategy based on international engagement that initially prioritized the imitation and adaptation of technologies developed in the advanced world; but more recently it has preferred domestic technological development, closely linked to knowledge supply and demand. This has enabled China to gain a leading position globally.
- The region failed to use the boom in commodity prices to develop a strategic vision targeting science, technology and innovation as the key development driver. As a result, the region's progress in terms of R&D was weak compared to that of China. Whereas, in 2000, both Latin America and China accounted for 1.6% of global investment in R&D, by 2012, the region was generating 2.8%, while China had reached a level of 11.8%. Moreover, the regionwide increase mainly reflected the growth of R&D investment in Brazil —where a small increase in the GDP share of that type of investment was combined with strong output growth, which meant that its share in the global total rose from 1% to 2%. In the rest of the region, the equivalent share grew by just 0.2 percentage points (from 0.6% to 0.8%).

Figure II.3

Global investment in research and development (R&D), 2000-2012

(Millions of dollars)

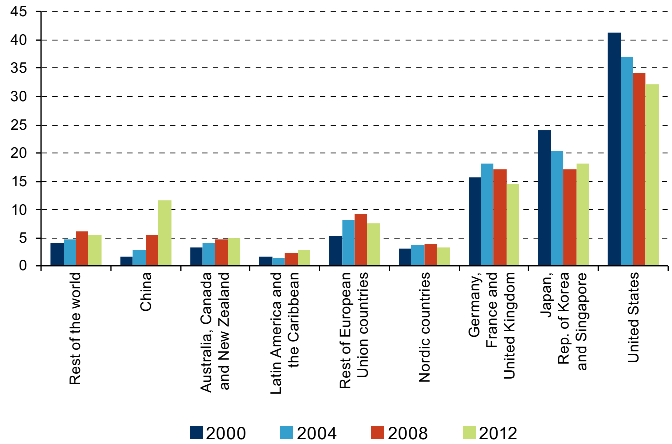


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, official information.

Figure II.4

Global distribution of expenditure on research and development (R&D) by country group, 2000-2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Bank, official information.

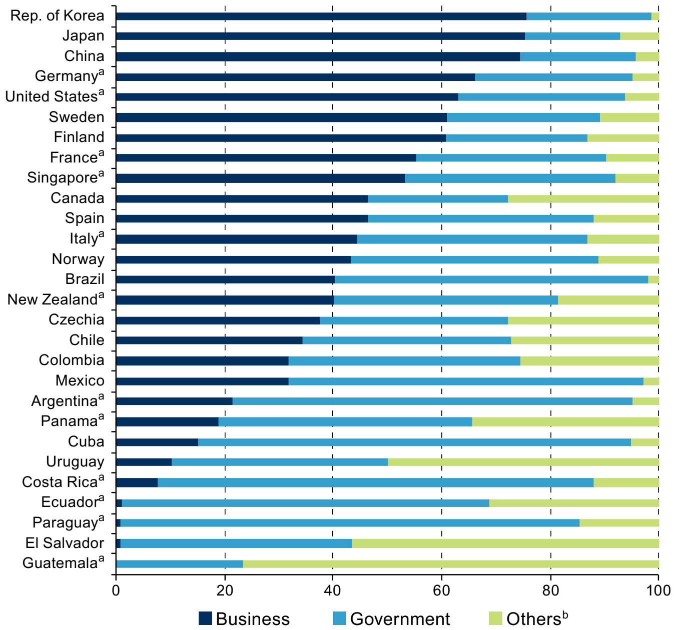
D. R&D is financed by the government and implemented by the education sector

- The region's R&D record has been stable; and the differences with respect to the industrialized and emerging countries have been maintained, in terms of both funding sources and the sectors in which the activities take place.
- Whereas, in the advanced countries, the private sector is the main funding source, in the region it is the public sector that makes the largest contribution. The government finances over 40% of total R&D in all countries except Chile, Ecuador, El Salvador and Uruguay. The business sector remains a minor player, surpassing 40% only in Brazil.
- The category "others", which includes foreign organizations, higher education institutions and private non-profit entities, does not contribute significantly to the funding of R&D, although it is the leading source in a few countries, such as Ecuador, El Salvador and Uruguay.
- In terms of implementation, the private sector is the leading player in the developed economies, whereas in Latin American countries, the most important agents are the education sector and the private non-profit sector. This demonstrates the production sector's weak commitment to innovation and technological change as drivers of business competitiveness.

Figure II.5

Expenditure on research and development (R&D) by financing sector, 2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from United Nations Educational, Scientific and Cultural Organization (UNESCO); Organization for Economic Cooperation and Development (OECD) and Ibero-American Network of Science and Technology Indicators (RICYT).

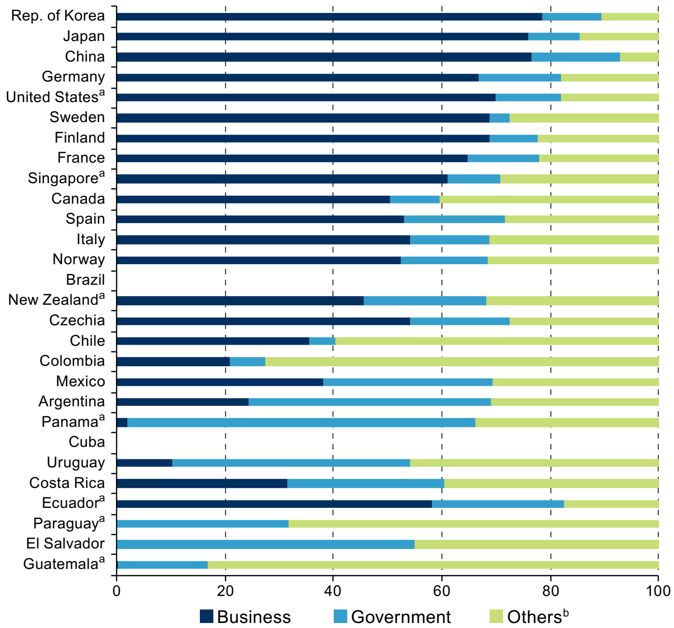
[a] Includes higher education institutions, foreign agencies and private non-profit entities.

[b] Figures from 2011 or 2010.

Figure II.6

Expenditure on research and development (R&D) by sector of execution, 2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from United Nations Educational, Scientific and Cultural Organization (UNESCO); Organization for Economic Cooperation and Development (OECD) and Ibero-American Network of Science and Technology Indicators (RICYT).

[a] Includes higher education institutions, foreign agencies and private non-profit entities.

[b] Figures from 2011 or 2010.

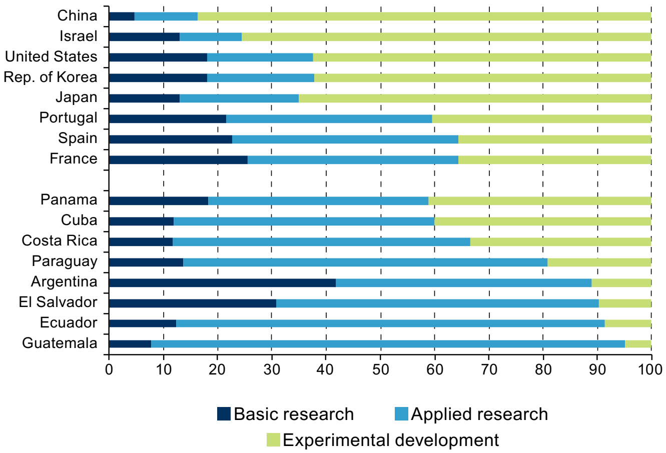
E. In Latin America, R&D is biased towards research, whereas experimental development predominates in the advanced countries

- Experimental research and development includes all creative work undertaken systematically to increase the stock of knowledge, including knowledge of mankind, culture and society, and its use to devise new applications. This definition involves three activities: basic research, applied research and experimental development, which are defined as follows:
  (i) Basic research is systematic original, theoretical or experimental work aimed at increasing the knowledge of a phenomenon or fact without considering any practical or direct application.
  (ii) Applied research also consists of original systematic work but, unlike the previous category, seeks to resolve a specific need or practical problem.
  (iii) Experimental development is aimed at new or improved production of materials, products, devices, processes or systems.
- In the technologically advanced countries, a large proportion of R&D investment is devoted to the experimental development of innovative products. In contrast, that type of development in Latin American countries absorbs only a small fraction of R&D spending, which is mostly devoted to basic and applied research.
- Figure II.7 shows how R&D spending is distributed between basic research, applied research and experimental development. The most advanced countries, such as the United States, Japan, Israel and the Republic of Korea, or those that have based their recent growth strategies on technological development, such as China, display a different pattern than the other countries considered, devoting between 60% and 80% of their R&D investment to experimental development. In the European countries, this proportion drops to 40%. The countries of the region channel a smaller proportion of expenditure into experimental development and devote most of such investment to experimental research. Nonetheless, there are considerable differences: Guatemala and Ecuador display a major bias towards applied research (over 80% of their total R&D), while countries such as Cuba and Panama invest 40% in experimental development. Nonetheless, unlike what happens in the most advanced countries, investment in experimental development is not done in firms but in laboratories or research centres.

Figure II.7

Selected countries: expenditure on research and development (R&D) devoted to experimental development, average 2010-2013

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from United Nations Educational, Scientific and Cultural Organization (UNESCO) and Ibero-American Network of Science and Technology Indicators (RICYT).

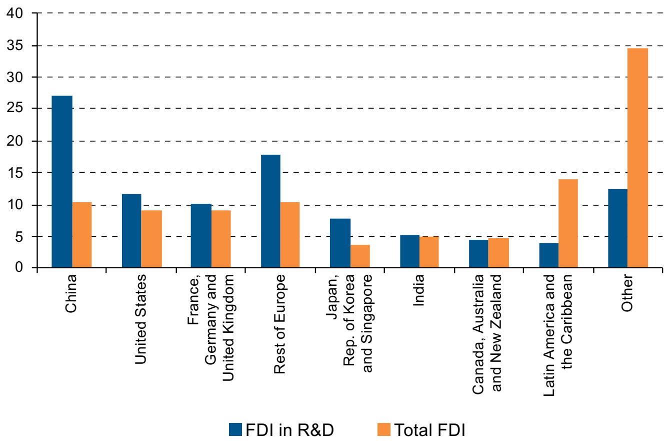
F. The region received just 4% of foreign direct investment in R&D

- Globalization has unfolded through global innovation networks, promoting open innovation —in other words methods of collaboration between different types of organization, which often include the payment of intellectual property licences. In a global innovation network, firms forge links with individuals, institutions (universities, government institutes) and other firms from different countries, to resolve problems and exploit new ideas. The firms may continue generating critical technologies internally, but many others can be developed in external networks, for which the firms use different methods. The two traditional models are joint endeavours with foreign entities through partnerships, joint ventures, joint development, the acquisition or sale of knowledge through R&D contracts, and the purchase or granting of licences. Open innovation is undertaken increasingly through joint venturing: capital investments in spin-offs or venture capital investment funds.
- Participation in global innovation networks results in the creation and dissemination of knowledge. It not only helps production and dissemination of codified knowledge, but it is also an important medium for transmitting tacit knowledge. Strictly speaking, the latter is any knowledge that cannot be codified or transmitted as information through documents, academic reports, lectures, conferences or other communication channels. It is transferred most effectively between individuals who share a social context and are located in neighbouring zones. The best-known forms of tacit knowledge are know-how, habits and mental models.
- One way of measuring the degree to which a country has integrated into a global innovation network is through foreign direct investment (FDI) in R&D. According to the Financial Times fDi Markets database, which has been recording cross-border investment announcements worldwide since 2003, Latin America received only 4% of the cross-border amounts invested in R&D between 2012 and 2015, compared to nearly 14% of FDI announcements for all sectors. The largest recipients of these foreign investments in R&D were China, India and the developed countries of Europe, followed by the developing countries in Asia. Investments in Latin America come mainly from the United States, the United Kingdom, Switzerland, Germany and Spain. The leading destination country for investments in the region was Brazil, which captured over 60% of the total in question between 2012 and 2015, followed by Chile, Panama, Mexico, Colombia and Costa Rica. Foreign direct investment in R&D is concentrated in the chemical industry (30%), communications (14%), the pharmaceutical industry (10%) and renewable energies (8%).
- Joining global innovation networks provides opportunities to strengthen the region's national innovation systems. Nonetheless, only a few countries have attracted this type of investment, unlike the pattern in the emerging Asian economies. Moreover, the spillovers from FDI in research and development could be meagre if the countries that receive them fail to expand capacities to absorb the new technologies, or if these do not match their industry's needs.

Figure II.8

Foreign direct investment (FDI) received in research and development (R&D), 2012-2015[a]

(Percentages of total world FDI)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Financial Times, *fDi Markets*, and United Nations Conference on Trade and Development (UNCTAD), *World Investment Report 2016*.

[a] The figures refer to amounts announced for new investment projects or the expansion of existing ones.

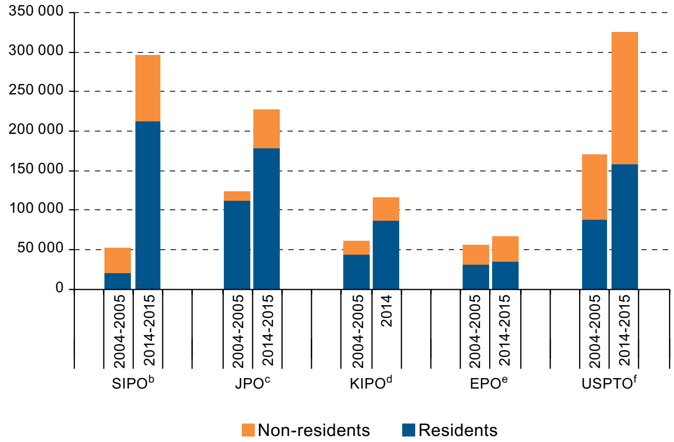
III. Intellectual property and patenting

A. Intellectual property use around the world is on the rise but concentrated in three countries

- Firms have several ways to appropriate the results of their R&D investments, including legal ones (such as patents), utility models and industrial designs; and strategic mechanisms, such as the industrial secret and complementary manufacturing capacities. Although the propensity to patent is highly asymmetrical and biased towards sectors such as pharmaceuticals, the number of applications and patents granted is a useful indicator when analysing innovative performance.
- The five leading intellectual property offices —the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (AIP) and the Chinese State Intellectual Property Office (IPO)— handle around 80% of patent applications worldwide. These agencies also account for 95% of the work done through the Patent Cooperation Treaty (PCT), to which most Latin American countries are parties, except Argentina, the Bolivarian Republic of Venezuela, Paraguay, the Plurinational State of Bolivia and Uruguay.
- Figure III.1 shows the number of patents granted by each of the five offices, as an average for the periods 2004-2005 and 2014-2015, with a breakdown by country of residence of the applicants. The United States patent office is the leader in terms of the number of patents granted, closely followed by the Chinese agency, which has grown very fast, to rank second worldwide.
- The number of patents granted in four of these offices has increased greatly; only the European one has seen moderate growth, expanding by just 18% in a decade, compared to the 84% in Japan, 89% in the Republic of Korea and 92% in the United States USPTO. In China, the number of patents awarded grew fivefold between 2004-2005 and 2014-2015.
- Lastly, unlike what happens in the trademark and patent offices of Asian countries, in the United States and European offices, the distribution between residents and non-residents is much more balanced. In the United States, over 160,000 patents have been issued to non-residents in the last few years, exceeding the number awarded to residents, which confirms that country's status as the world's largest knowledge market for innovative products.

Figure III.1

Selected countries: patents granted, by residency and patient registry office, average 2004-2005 and 2014-2015[a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from United States Patent and Trademark Office (USPTO); European Patent Office (EPO); Japan Patent Office (JPO); Korean Intellectual Property Office (KIPO); State Intellectual Property Office (SIPO) and statistics from IP5 Offices [online] http://www.fiveipoffices.org.

[a] Average for each period. The 2014-2015 data for the Republic of Korea only include 2014. Residency is defined by the country of residency of the patent holder mentioned first in the application. In the data for the Republic of Korea and China, residency is established by country of origin of the patent applicant.

[b] State Intellectual Property Office of China.

[c] Japan Patent Office.

[d] Korean Intellectual Property Office.

[e] European Patent Office.

[f] United States Patent and Trademark Office.

B. The region's level of patenting remains very low

- The United States Patent and Trademark Office (USPTO) is the largest patent office in the world. A review of the number of patents registered there gives an idea of the use of intellectual property mechanisms, particularly patents, which is associated with the capacities of countries to innovate and generate technological developments, or their potential to serve as knowledge markets.
- Table III.1 shows the country-of-origin distribution of the number of patents granted by USPTO to non-residents in 2002-2005 and 2012-2015. Although the region's share increased slightly from 0.4% to 0.5%, new players made a forceful entry into the knowledge market and rearranged the ranking.
- Among non-residents, Japan remains the leading participant in USPTO, followed far behind by Germany. The Republic of Korea and China also have significant participation. The Korean share rose from 5.1% of the total at the start of the new millennium to 10.7% in 2012-2015. China's share grew from 0.6% to 4.5%, overtaking France and the United Kingdom. Israel and India also recorded significant increases, whereas the contribution by Latin American and Caribbean countries grew only marginally.

Table III.1

Selected countries: distribution of patents granted by the United States Patent and Trademark Office (USPTO) to non-residents, 2002-2005 and 2012-2015

(Percentages)

	2002-2005	2012-2015
Japan	42.1	34.2
Germany	13.3	10.5
Taiwan (Province of China)	7.9	7.6
Republic of Korea	5.1	10.7
United Kingdom	4.6	4.2
France	4.5	4.2
Canada	4.4	4.6
Italy	2.2	1.8
Sweden	1.8	1.7
Netherlands	1.8	1.6
Switzerland	1.6	1.6
Israel	1.3	2.1
Australia	1.2	1.2
Finland	1.0	0.8
Belgium	0.8	0.7
Hong Kong (Special Administrative Region of China)	0.7	0.5
Austria	0.7	0.7
Denmark	0.6	0.7
China	0.6	4.5
Singapore	0.5	0.6
Latin America	0.4	0.5
India	0.4	1.7
Other countries	2.2	3.1
Total	100.0	100.0

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from United States Patent and Trademark Office (USPTO).

C. The region is lagging behind the Asian countries

- Although the share in total patents granted by USPTO indicates the importance of countries or regions in the international scientific and technological arena, patent rates per million inhabitants is a better metric of technological development. Progress in the techno-economic paradigm relates to the countries' capacity to generate knowledge and use mechanisms to protect it. According to USPTO, the patenting rate per million inhabitants rose from 13.5 in 1980-1984 to 35.9 in 2010-2014, driven strongly by the advanced economies and a number of emerging ones, such as the Republic of Korea and Singapore, which multiplied their indicators by over 500 and by 90, respectively. The countries that follow the United States, which has the largest number of patents per million inhabitants in its own patent and trademark office, are Japan, Israel, the Republic of Korea and Switzerland, with over 200 patents per million inhabitants.
- Latin America had an average of 0.9 patents per million inhabitants in 2010-2014, well below the levels in developed countries and also fewer than the world average. Chile, Costa Rica and Uruguay display the best results, in contrast to the Bolivarian Republic of Venezuela and Peru which have not made any significant progress in three decades.
- Figure III.2 shows a set of countries that had rates similar to those of Latin American ones in 1992-1995. Since then, Malaysia has achieved a sustained increase in the number of patents per million inhabitants. Rates in Portugal, Poland and China were even lower than Latin American ones at the start of the twenty-first century, but since 2004-2007, these countries have raised their indicators and now have four times more patents per inhabitant than their Latin American counterparts.

Table III.2

Selected countries: patents granted by the United States Patent and Trademark Office (USPTO), 1992-1995 and 2012-2015[a]

(Number of patents per million inhabitants)

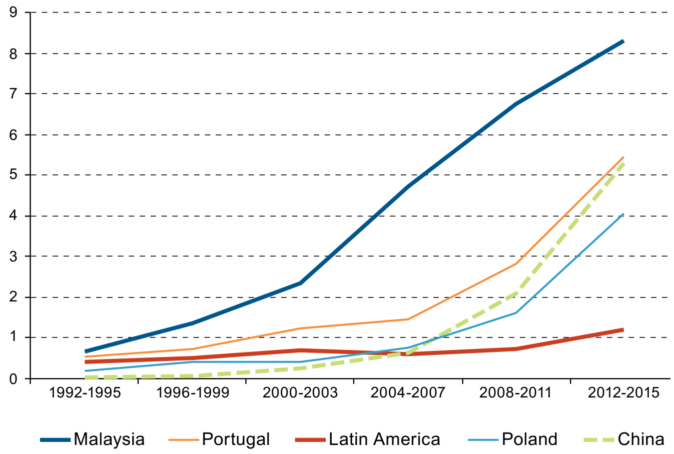
	1992-1995	2012-2015
United States	237.5	469.2
Japan	186.2	427.1
Israel	71.5	403.5
Republic of Korea	20.6	339.0
Switzerland	176.7	305.1
Singapore	14.7	172.8
World	**19.9**	**42.6**
Spain	4.3	17.6
Malaysia	0.7	8.3
Portugal	0.5	5.5
China	0.0	5.3
Costa Rica	1.7	3.4
Chile	0.5	3.4
Russian Federation	0.6	3.0
Uruguay	0.3	2.4
Argentina	0.9	1.8
Mexico	0.5	1.6
Brazil	0.4	1.6
Latin America and the Caribbean	**0.4**	**1.2**
Cuba	0.1	1.1
Venezuela (Bolivarian Republic of)	1.4	0.7
Colombia	0.2	0.5
Ecuador	0.1	0.3
El Salvador	0.0	0.2
Peru	0.1	0.1

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from United States Patent and Trademark Office (USPTO) and the World Bank.
[a] Average for each year.

Figure III.2

Selected countries: patents granted by the United States Patent and Trademark Office (USPTO), 1992-2015

(Number of patents per million inhabitants)



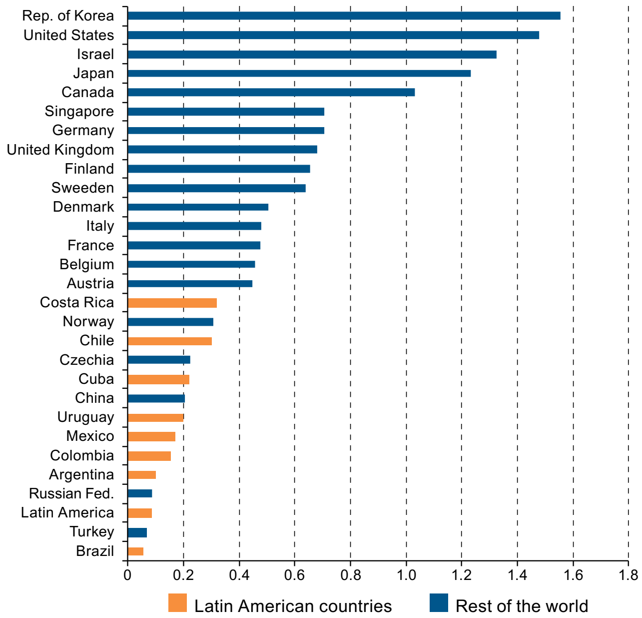
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from United States Patent and Trademark Office (USPTO) and the World Bank.

D. The efficacy of R&D investment in generating patents

- Assuming the existence of a direct relation between R&D investment and the number of patents obtained, the efficacy of R&D expenditure can be measured by the number of patents obtained in a three-year period per US$ 1 million invested in R&D in the same period.
- This indicator suggests four groups of countries. Firstly, a group that has a high level of technological development and great capacity to convert R&D investment into new goods and services or patentable processes (Republic of Korea, the United States, Israel and Japan). In these countries, for every US$ 1 million invested on average between 2011 and 2013, between 1.3 and 1.5 patents were obtained in 2013-2015.
- In the second group of countries (Singapore, Germany, the United Kingdom and Finland, among others), which have substantial capacity but less than those of the first group, the indicator fluctuates between 0.6 and 0.7. The difference between this group and the first reflects the fact that European countries patent more in OEP than in USPTO.
- The third group, led by Denmark, Italy, France and Belgium, represents the segment for which the efficiency indicator is between 0.4 and 0.5. Costa Rica, Norway, Chile, Czechia, Cuba, China and Uruguay form part of the set of countries with efficiency indicators between 0.2 and 0.4. Lastly, the fifth group contains countries with indicators below 0.2 (Mexico, Colombia, Argentina and Brazil, among the Latin American ones. Their R&D expenditure generates fewer patents than in developed countries, owing to the lower new-knowledge-generating capacity of their universities, research centres and firms; their greater tendency to import and adapt technology; and weaker links between their universities and the business sector.

Figure III.3

Selected countries: efficacy of investment in research and development as measured by patents[a]



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from United States Patent and Trademark Office (USPTO); World Bank and UNESCO Institute for Statistics.

[a] The graph shows the total number of patents obtained by each country from USPTO between 2013 and 2015, relative to their average research and development expenditure in 2011 and 2013, measured in millions of dollars at current prices. A time lag between the R&D spending and the number of patents granted is included to reflect the dynamic between that investment and patents.

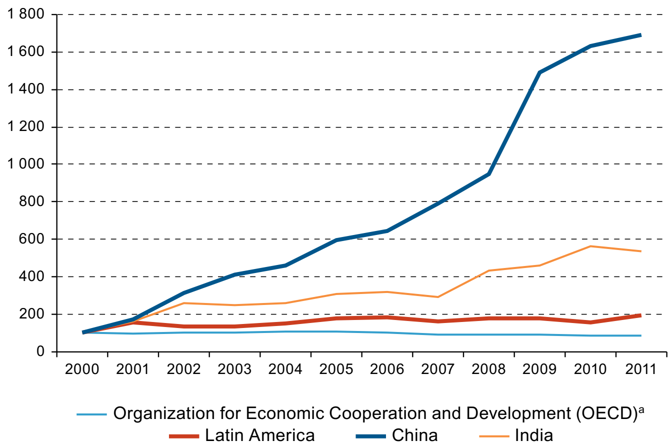
E. The growth of patenting in the region is weak

- Triadic patents are those requested simultaneously in three of the most important offices around the world: USPTO of the United States, Europe's OEP and Japan's JPO. The number of triadic patents is a good indicator of innovations of global scope, and it reduces the bias that arises from considering just one market, such as the United States.
- Between 2000 and 2011, the number of triadic patents obtained by the countries of the Organization for Economic Cooperation and Development (OECD) (excluding Chile and Mexico) declined slightly. In contrast, the indicator rose in the non-OECD countries, mainly thanks to growth in China and India. Latin America doubled its number of triadic patents in that period.
- An analysis of the patenting dynamic in a number of countries that had a similar level to that of Latin America early in the 2000 decade, highlights the major growth of Japan and Taiwan province of China. While Latin America increased its share in the total number of applications for triadic patents, from 0.14% in 2000 to 0.30% in 2011, China's share rose from 0.16% to 2.90%, and that of Taiwan province of China increased from 0.09% to 1.0%, overtaking the region as early as 2006. On the other hand, the region closed the gap with respect to certain countries, such as Spain, whose share decreased slightly, and Australia, which was already far ahead of Latin America at the start of the century.

■ **Figure III.4** ■

Selected countries: triadic patents obtained, 2000-2011

(Index: 2000=100)

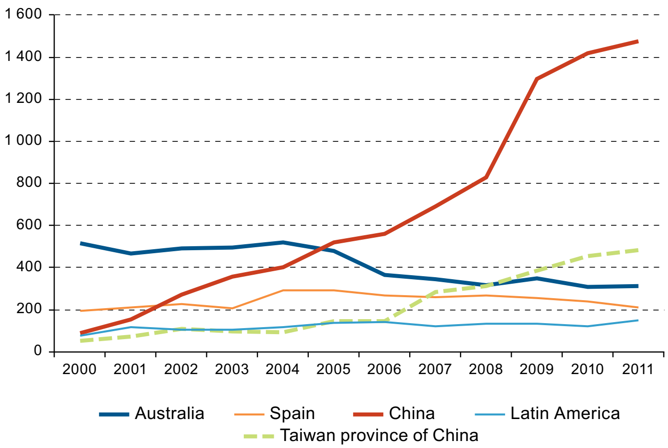


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

[a] Excluding Chile and Mexico.

■ **Figure III.5** ■

Selected countries: triadic patents, 2000-2011



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

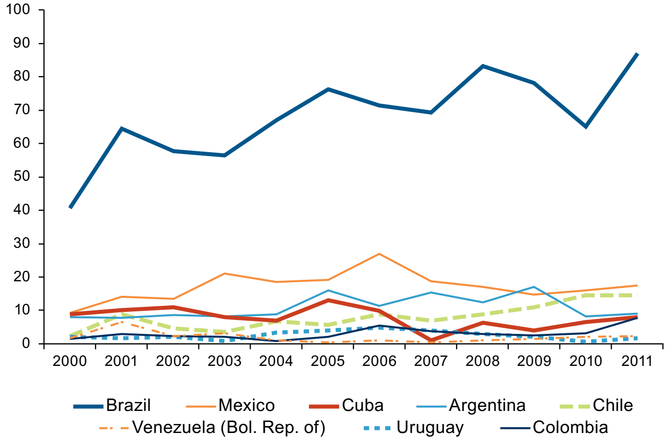
F. Brazil is the Latin American country with most patents overall and Uruguay has the most per capita

- Brazil, Mexico, Chile, Argentina, Cuba, Colombia, the Bolivarian Republic of Venezuela and Uruguay are the only countries in the region that had over 20 triadic patents accumulated in 2000-2011. Among these, Brazil accounts for 56% of the total, Mexico for 14%, Argentina 9%, Chile 6.6% and Cuba 6.4%.
- A review of the average number of triadic patents per million inhabitants between 2006 and 2011 shows that Uruguay, Chile and Cuba had the highest indicators, posting values of 0.70, 0.60 and 0.46, respectively. The average for Latin America and the Caribbean was 0.21. The largest changes relative to 2000-2005 were Chile, which improved its position, and Cuba, which lost its leadership in the region. Although of smaller magnitude, the rise in the indicator in Colombia and its fall in the Bolivarian Republic of Venezuela are worth noting.

Figure III.6

Latin America (selected countries): cumulative number of triadic patents, 2000-2011[a]

(Number of patents)



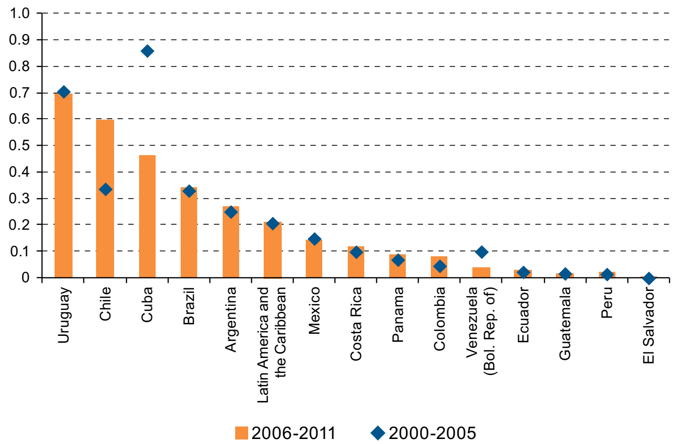
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

[a] By date of priority and country of residence of the inventor (fractioned count). Only includes Latin American countries that had over 20 patents accumulated between 2000 and 2011.

Figure III.7

Latin America and the Caribbean (selected countries): average number of triadic patents 2006-2011 and 2000-2005[a]

(Number of patents per million inhabitants)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

[a] By date of priority and country of residence of the inventor (fractioned count).

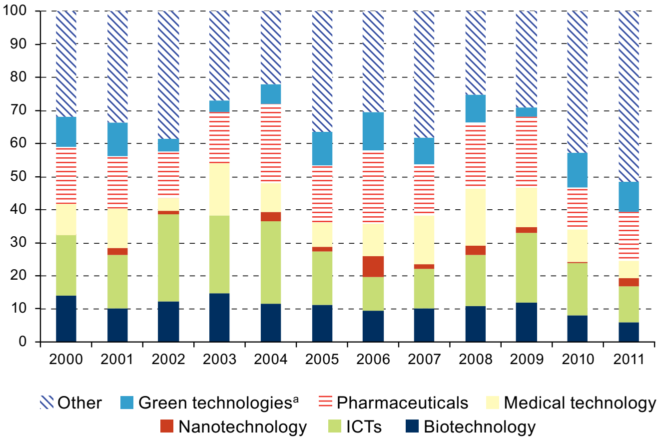
G. The most patented technologies in the region are pharmaceuticals and ICTs

- According to data on triadic patents in Argentina, Brazil, Chile and Mexico, pharmaceutical technology is most patented by the region, accounting for 18% of the total in 2006-2011, followed by information and communication technologies (ICTs) and medical technologies, accounting for 14% and 11%, respectively.
- Triadic pharmaceutical patents in the region represent less than 0.4% of the world total, and those of ITCs an even smaller percentage. In the case of nanotechnology patents, while accounting for just 3% of the total obtained by Latin American countries between 2006 and 2011, they represent over 0.4% of triadic nanotechnology patents around the world, making this the technology in which the region has greatest participation.
- Despite this progress and the region's potential, Latin American patents continue to represent a minimal fraction of the global total.

Figure III.8

Latin America (selected countries): distribution of triadic patents by technology 2000-2011

(Percentages)



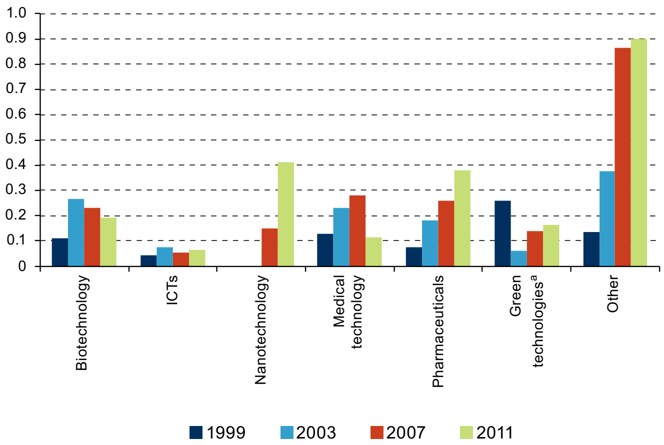
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

[a] Green technologies include climate change mitigation technologies relating to building; transport; water; energy generation, distribution or transmission; the capture, storage or withdrawal of greenhouse gases; and environmental management technologies.

Figure III.9

Latin America (selected countries): distribution of triadic patents by technology 1999-2011

(Percentages of the world total)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), OECD Patent Database.

[a] Green technologies include climate change mitigation technologies relating to building; transport; water; energy generation, distribution or transmission; the capture, storage or withdrawal of greenhouse gases; and environmental management technologies.

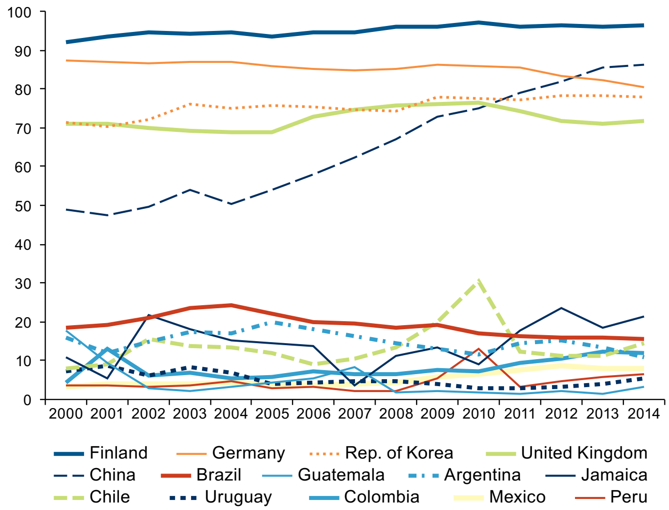
H. In the region, non-residents apply for more patents than residents; in the advanced economies the opposite occurs

- The distribution of patenting between residents and non-residents within countries is relevant for identifying their domestic capacities and ascertaining who is appropriating the knowledge registered in a country, whether generated there or elsewhere.
- In developed countries (Germany, Finland and the United Kingdom), national applicants drive the growth in patenting; and in China and the Republic of Korea there was a significant increase in the number of applications from residents compared to those of non-residents. In the case of China, the pattern of patenting has shifted to a much greater proportion of residents.
- In Latin American and Caribbean countries, non-residents determine the level and dynamic of patenting, a situation that has not changed in the last 15 years. Brazil has the largest percentage of resident applications in the national patent office: 19% of the total in 2000-2014, although the figure has dropped in recent years. In other countries in the region, the proportions are much smaller, around 4% and 5%, for example, in Colombia, Guatemala, Mexico, Peru and Uruguay.
- The region's numbers are more worrying in the light of what is happening in other emerging economies, such as Poland, which, starting from a similar position to that of the Latin American countries, in little over a decade has tripled the share of residents in total patents granted, attaining the levels of the most technologically advanced countries.

Figure III.10

Selected countries: share of residents in applicants to national patent offices, 2000-2014

(Percentages)



Source: World Intellectual Property Organization (WIPO), Statistics [online database] http://www.wipo.int/ipstats/en/.

I. The region's share in the knowledge market is marginal and is slipping further behind that of the developed world

- There are other variables to consider when measuring the countries' technological capabilities, which help to build a more thorough picture of their capacities and innovation processes, as well as the support they provide for the development of techno-economic paradigms.
- The number of patent applications abroad is one of the variables that reflects the progress made by countries in generating knowledge for the development of new technologies.
- In the more advanced countries, there has been a substantial increase in the number of patent applications from residents abroad, as shown in the data for China, Finland, Germany, Japan, the United Kingdom, the United States and the Republic of Korea.
- This differs from the situation in Latin American countries, where patent requests from nationals abroad are at very low levels, which highlights the need to generate mechanisms and incentives to strengthen scientific and technological capacities for developing new knowledge. While patent applications by Brazilians and Mexicans abroad in 2000-2014 grew from 604 to 2,058 and from 340 to 951, respectively, those made by Koreans abroad grew from 12,956 to 66,483, and those of Chinese residents from 1,100 to 36,767. This demonstrates the tremendous growth of their capacity to generate new technologies and their preparedness to benefit from technological progress.

■ **Figure III.11** ■

Selected advanced countries: patent applications, 2000-2014

(Number of applications)

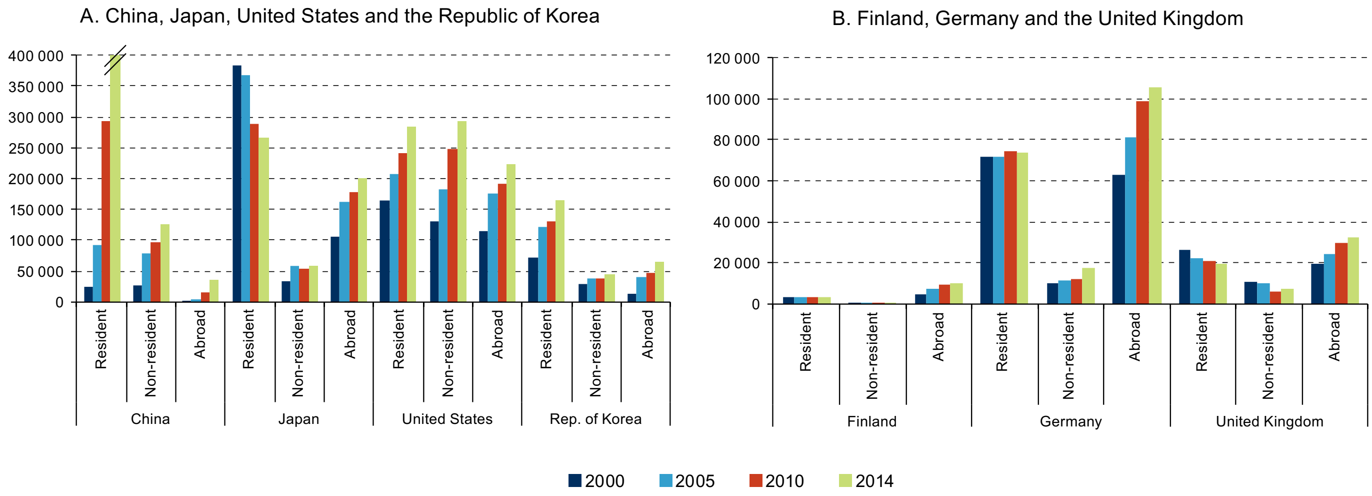
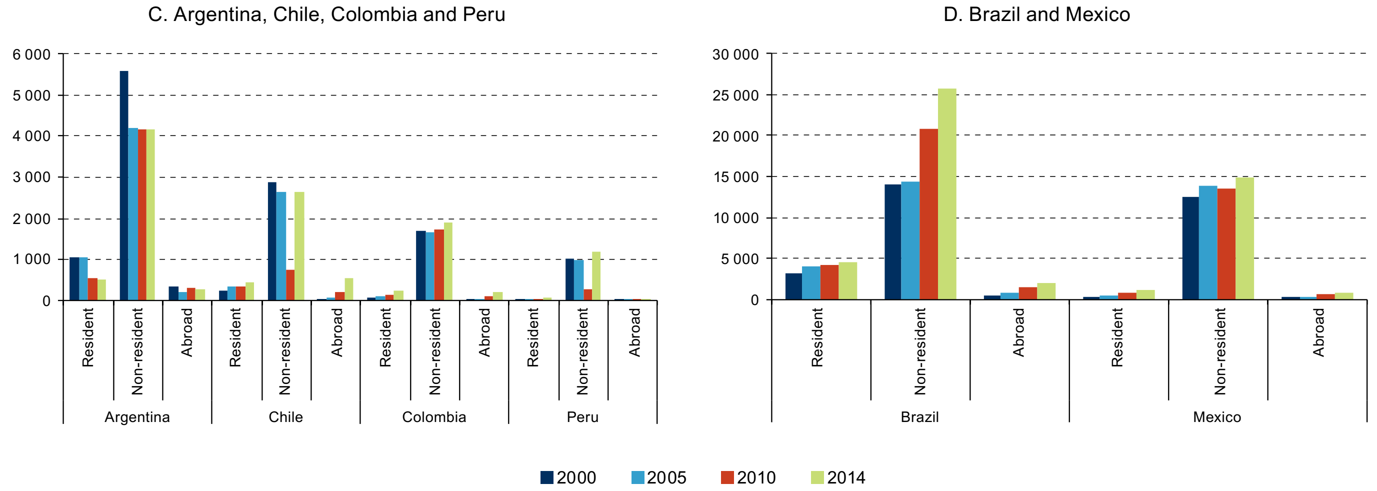


Figure III.11 (concluded)



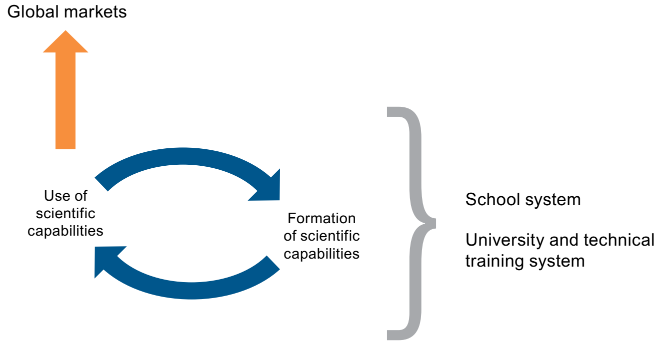
Source: World Intellectual Property Organization (WIPO), Statistics [online database] http://www.wipo.int/ipstats/en/.

IV. Human resources and scientific capacities

A. Successful innovation systems are based on highly skilled human resources

- The new context of knowledge-based economies and the advance of the digital economy have drawn attention to the importance of human capital for sustaining countries' innovative momentum. Building advanced human capital is central to technological development strategies at both the country and the enterprise level, in addition to the social need for universal education coverage.
- The experience of the developed and recently industrialized countries shows that human resources and the generation of an infrastructure of excellence for R&D leading to new products and services (the national scientific and technological research system) are decisive for patterns of economic, scientific and technological growth, and for integration into global production and knowledge networks.
- Latin America has a shortage of researchers and personnel engaged in R&D, owing to the failings of its education systems and weak demand for scientific capabilities. The region's school systems do not produce the quality outcomes that more developed countries obtain; in some cases this is compounded by low rates of school coverage.
- This fragile school system sends students to a university system that is far from the knowledge frontier. This dynamic generates a flow of doctoral students that is insufficient compared to that of developed countries. The weak formation of scientific capabilities and advanced human capital can be seen in the use of these capacities in national innovation systems: their laboratory network is small and they lack globally competitive technological industries. Failings in the formation and use of scientific capabilities feed into a spiral of underdevelopment and hinder industrial diversification and structural change.
- Given these prospects, it is crucial to improve national scientific and technological development strategies. Public policies are needed to promote national innovation systems and create the environment and incentives needed to underpin the professional development of the researchers and institutions comprising them. This would support creation of the stock of knowledge needed to be able to perform effectively in the global value chains of the knowledge economy.

■ **Diagram IV.1** ■
Capacity flows



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

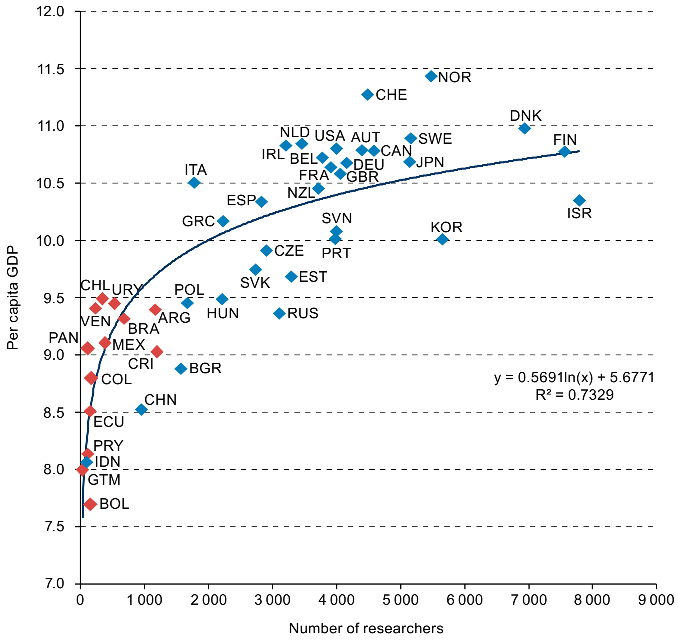
B. Human resources for innovation are associated with per capita income

- The creation of a critical mass of researchers working on R&D activities is associated with rising levels of per capita income, as shown in figure IV.1. The most innovative countries, which also have the highest per capita incomes, have more researchers per million inhabitants than the technologically weaker. The Latin American countries have the lowest per capita income levels of the sample of countries and also the smallest amount of human resources devoted to R&D.
- The new technology paradigms, such as ICTs and nanotechnology, as well as concern for sustainability and climate change and changes in the international organization of production have increased the demand for skilled human resources for research and development and for business management in new knowledge areas. At the same time, in an open economy context, the mobility of talent and exchange of specialized personnel is increasingly important. Having a critical mass of specialized human resources available is a priority for developed and developing countries alike.

Figure IV.1

Selected countries: stock of human resources engaged in research and development and per capita income, average 2009-2012

(Logarithms of per capita GDP and number of researchers per million inhabitants)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of figures from World Bank.

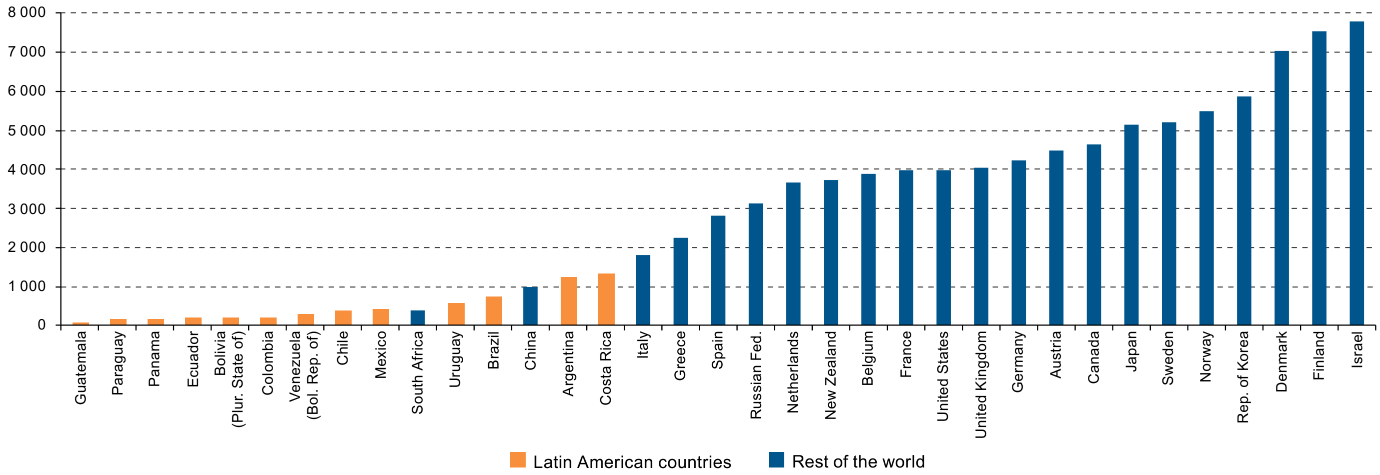
C. The region has 520 researchers per million inhabitants

- In 2010, the Latin American countries had on average 520 full-time equivalent (FTE) researchers per million inhabitants, in contrast to the industrialized countries which have between 2,000 and 8,000.
- Figure IV.2 distinguishes several groups of countries. In the first, comprising Colombia, Ecuador, Guatemala, Panama, Paraguay and the Plurinational State of Bolivia, there were fewer than 200 researchers FTE per million inhabitants. Unlike the other countries mentioned, Ecuador has recorded a significant increase in researchers per million inhabitants over the last decade, with the number rising from 40 in 2001 to 118 in 2011. The second group has between 200 and 500 researchers per million inhabitants, and includes the Bolivarian Republic of Venezuela, Chile and Mexico. Brazil and Uruguay comprise the third group, in the range of 500 to 1,000 researchers per million inhabitants. Argentina and Costa Rica are the only Latin American countries that exceed 1,000 FTE researchers per million. The latter country has increased its number of researchers per million inhabitants tenfold from 130 in 2003 to 1,320 in 2011, making it the regional leader. Nonetheless, it is still behind the industrialized countries, including the most backward ones, such as Italy, Greece and Spain, which all have over 1,500 researchers FTE per million inhabitants. Most of the industrialized European countries, along with the United States and Japan, have between 3,000 and 6,000 researchers per million inhabitants, while the economies that are on the technological frontier, such as Finland and Israel, have over 7,000.
- Figure IV.2 illustrates Latin America's high degree of heterogeneity, ranging from Guatemala with 26 researchers per million inhabitants, to Costa Rica with 1,320. The increase in the regional average, from 330 to 520 researchers per million inhabitants between 2010 and 2012, is accounted for by Argentina and Brazil, which have nearly half of the region's population and 70% of its researchers.

Figure IV.2

Selected countries: full-time equivalent researchers, average 2010-2012

(Number of persons per million inhabitants)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from United Nations Educational, Scientific and Cultural Organization (UNESCO).

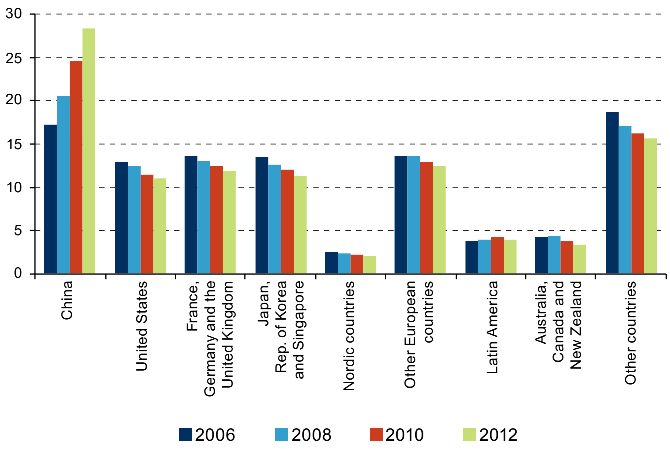
D. The region's share in the total number of people working in R&D is small

- In 2012, there were over 11 million full-time equivalent researchers in the world, working on R&D. Development strategies based on innovation and knowledge, and the demand for human resources specialized in science and technology explain the numbers engaged in research. For that reason, the countries with the largest absolute number of researchers are China and the United States, followed by those of the European Union, Japan and the Republic of Korea.
- The number of researchers in China and India has increased considerably. The former, where the number grew from 1.5 million in 2006 to 3.2 million in 2012, accounts for over a quarter of all people doing research worldwide. Most of the advanced country grouping shown in figure IV.3 have increased their researchers in this period, but more slowly than these emerging countries, so they have lost relative share.
- Latin America's overall share in the total has been stable, at around 4%, thanks to the performance of Brazil. This country has constantly increased its share since the start of the 2000 decade, to surpass 250,000 researchers (around 60% of the region's total). The second largest contributor is Mexico, followed by Argentina and Chile. Ecuador has tripled its number of researchers over the last few years and now has 1% of the region's researchers. Many countries, such as Colombia, Cuba, Peru, Uruguay and the Bolivarian Republic of Venezuela lack data on this variable.
- Two factors that determine the availability of human resources for research are the capacities of the education system (quality and coverage of the school and higher education systems), and those of research centres and national innovation ecosystems.

Figure IV.3

Global distribution of personnel engaged in research and development, by country groups, 2006-2012

(Percentages)

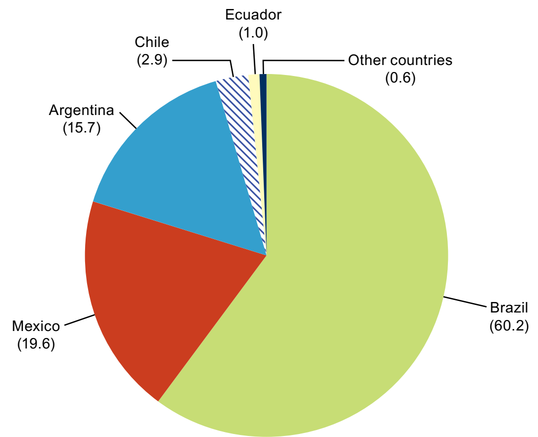


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from UNESCO Institute for Statistics.

Figure IV.4

Latin America: distribution of personnel devoted to research and development, average 2009-2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from UNESCO Institute for Statistics.

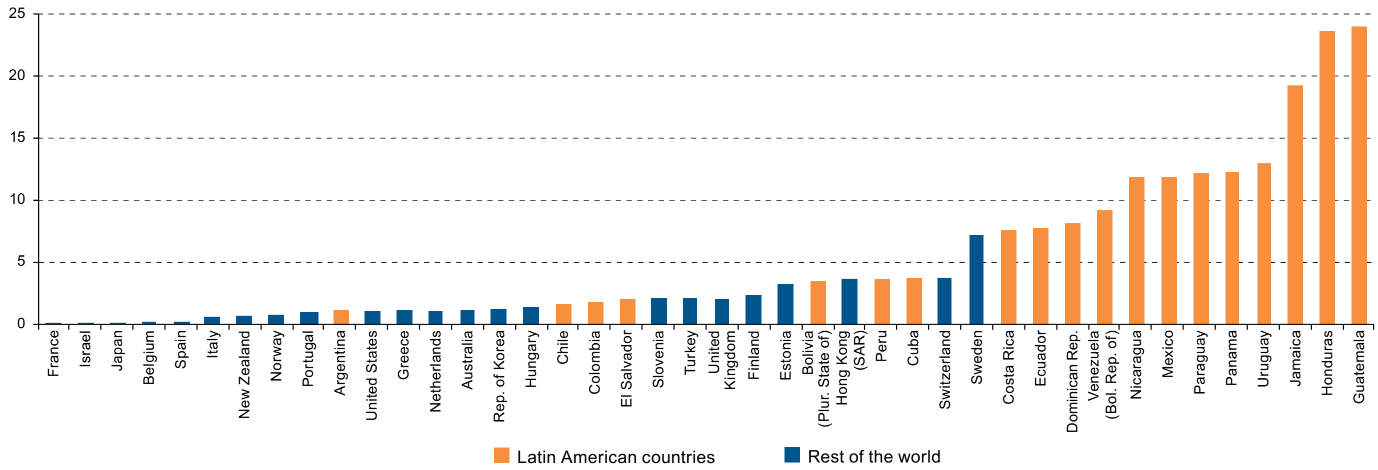
E. Many Latin American countries have high rates of school dropout

- The quality and number of researchers depends on their educational track record, from basic education to postgraduate training. The first rung on the ladder, basic education, should have the coverage rate and quality sufficient to ensure that universities and postgraduate schools have an adequate number of students and of the capacities needed to train researchers. In this regard, the region's countries have a major shortfall which urgently needs to be overcome.
- Figure IV.5 shows the proportion of adolescents of first-cycle secondary-school age who are not attending school. The global initiative on out-of-school children believes that children who fall two or more years behind are at serious risk of school dropout.
- The technologically advanced countries, such as France, Israel and Japan, make the most of all of their human resources: all adolescents complete secondary school studies. Argentina, Chile and Colombia have made efforts to improve their school coverage and have cut out-of-school rates to between 1% and 2%, like developed countries such as Australia and the United States. This proportion is slightly higher, but still below 5%, in Cuba, Peru and the Plurinational State of Bolivia. By contrast, the remainder of the Latin American countries record higher rates: even in countries that have largely overcome the lowest levels of underdevelopment, such as Mexico and Uruguay, surprisingly, one in every 10 adolescents is not attending school. Honduras and Guatemala have dramatic figures: one quarter of their adolescents are not in the school system.
- The pattern shown in the graph serves as a basis for what will be reviewed below on the tertiary education enrolment rate, because school pupils who do not complete their secondary education cannot access that level.

Figure IV.5

Selected countries: proportion of adolescents of first-cycle secondary-school age who are outside the school system, average 2009-2013

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from UNESCO Institute for Statistics.

F. The results of the Programme for International Student Assessment (PISA) reflect the poor quality of school education

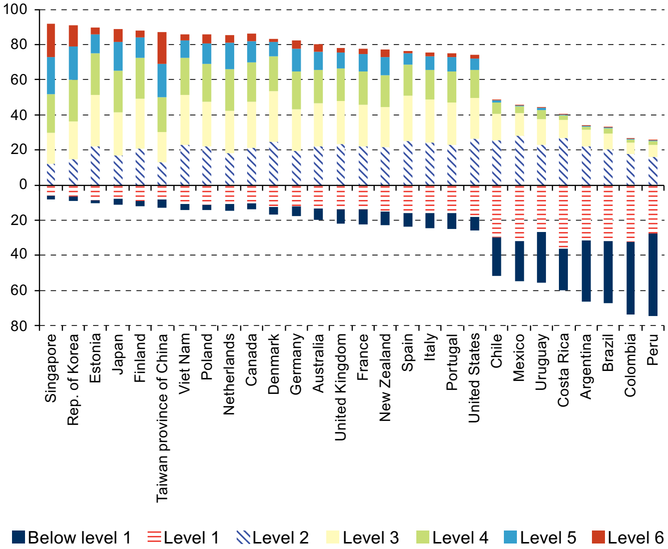
- In the Latin American countries, the quality of the teaching-learning process is far below the level achieved in the developed economies. The Programme for International Student Assessment (PISA) run by the Organization for Economic Cooperation and Development (OECD) evaluates learning outcomes by measuring knowledge and skills acquired by students for their full participation in the knowledge society. In the mathematics and science tests, the region's students have poor results, particularly compared to the emerging countries of Eastern Europe or Southeast Asia, which have overtaken Germany and the United Kingdom in this regard.

- Estonia, Viet Nam and Poland are among the countries with the best results, alongside Japan, Finland, the Republic of Korea and Canada, which have traditionally been renowned for making excellence in scientific training a national priority. The poor performance of the region's countries is an obstacle for putting education on a path of excellence. The countries need to continue improving educational coverage and prioritize an improvement in teaching quality.

■ **Figure IV.6** ■

Selected countries: distribution of students by level attained in mathematics in the Programme for International Student Assessment (PISA), 2012

(Percentages)

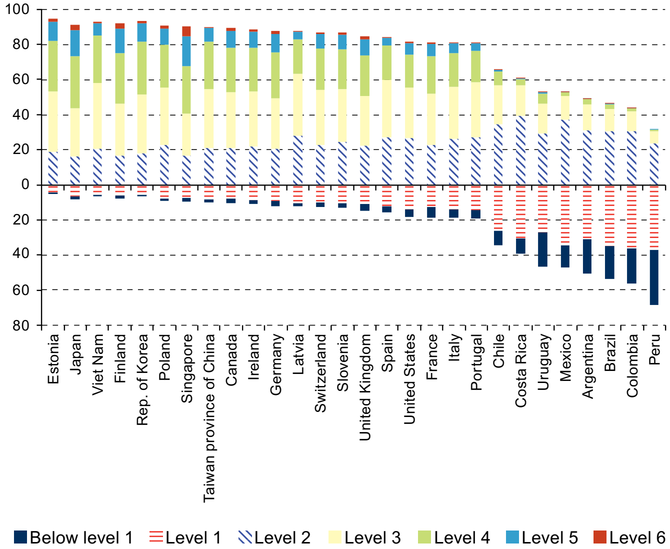


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), Programme for International Student Assessment (PISA).

■ **Figure IV.7** ■

Selected countries: distribution of students by level attained in sciences in the Programme for International Student Assessment (PISA), 2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), Programme for International Student Assessment (PISA).

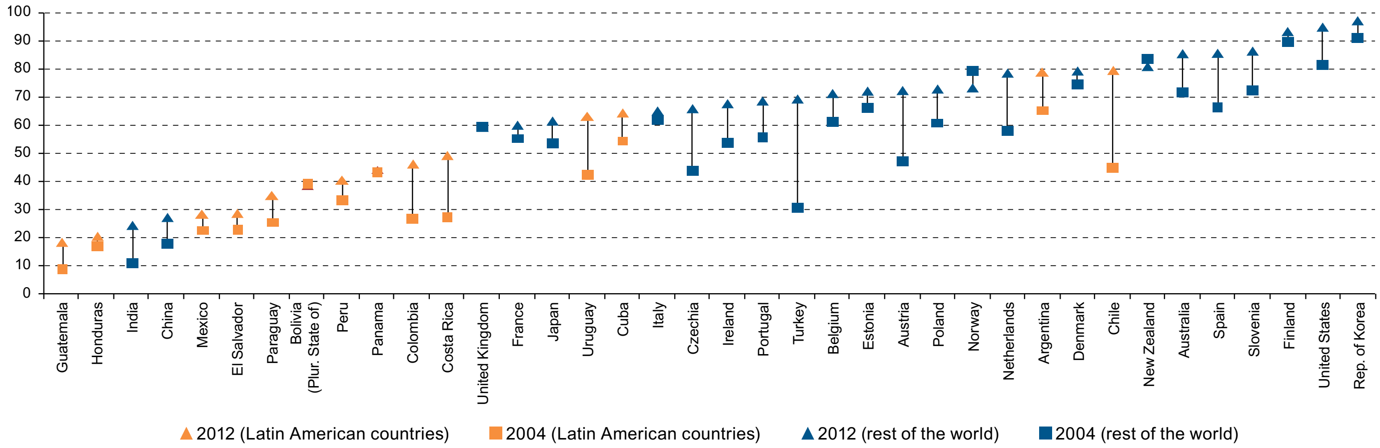
G. Few of the region's countries have an adequate tertiary education enrolment rate

- In countries where most students do not receive university training, there are few postgraduate students oriented towards R&D, with the consequent lack of human resources for scientific and technological activities. The gross tertiary education enrolment rate measures the flow of young people entering higher education out of the total population of their age. The region's enrolment rate averaged 43% in 2012.
- The countries of the region fall into four groupings. The first comprises Argentina and Chile, which have enrolment rates above 75%, in other words similar to levels in Australia or Denmark. The second group (Cuba and Uruguay) has enrolment rates of between 50% and 75%, comparable to those of France or Japan. The third group consists of Colombia, Costa Rica, Panama, Paraguay, Peru and the Plurinational State of Bolivia with rates of between 25% and 50%, much lower than those of the industrialized countries. The final group comprises El Salvador, Guatemala, Honduras and Mexico, all of which have rates below 25%.
- The region's countries increased their enrolment rates between 2004 and 2012 —particularly Chile, where the rate rose by 34 percentage points, and Costa Rica, Colombia and Uruguay with increases of over 20 points.
- Increasing education coverage at the tertiary level and encouraging the creation of training centres of excellence should be prioritized in all of the region's countries, since this will enable them to lay the foundations for more equitable participation in the knowledge economy.

■ **Figure IV.8** ■

Selected countries: trend of the gross tertiary education enrolment rate, 2004-2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from UNESCO Institute for Statistics.

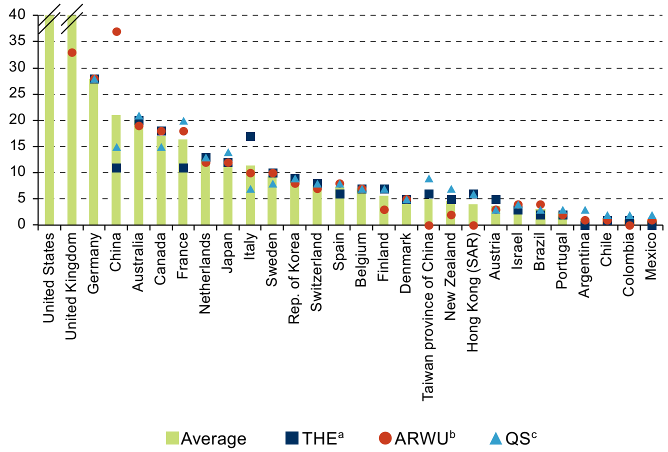
H. Only 2% of the world's top universities are Latin American

- In addition to the proportion of young people entering higher education, an analysis of the national innovation system and human resources available for research should also consider the quality of the academic institutions that perform R&D and train researchers and technical and scientific personnel. The leading countries in technological and innovation capacities are also those with the largest number of universities rated excellent worldwide.
- The indicators assess the quality of academic institutions based on data on the number and impact of indexed publications, the number of students who have received Nobel laureates or other awards, or the number of academics with doctorates. Figure IV.9 shows the results of three prestigious rankings: Times Higher Education (THE), the QS ranking and the Academic Ranking of World Universities (ARWU) of Shanghai University.
- According to the average of these rankings, about 100 of the top 400 universities in the world are in the United States, and 14 are in United Kingdom. These two countries jointly account for 36% of the total, compared to 32% in the rest of Europe and 19% in other industrialized countries. Latin America has 2% of the best universities, with an average of eight universities, and ranging between four and 12 according to different classifications.
- Brazil is the region's best placed country, with three universities in the top 400, followed by Argentina, Chile, Colombia and Mexico, with an average of just one. The fact that most of the region's universities are concentrated in the lower half of the ranking highlights the need to increase the quality of tertiary education institutions.

■ Figure IV.9 ■

Selected countries: universities among the world's 400 best according to international rankings, 2015

(Number of universities)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Center for World-Class Universities (CWCU), Shanghai Jiao Tong University, Academic Ranking of World Universities (ARWU); QS University Ranking® and TES Global, Times Higher Education World University Ranking

[a] Times Higher Education World University Rankings.

[b] Academic Ranking of World Universities.

[c] QS World University Rankings®.

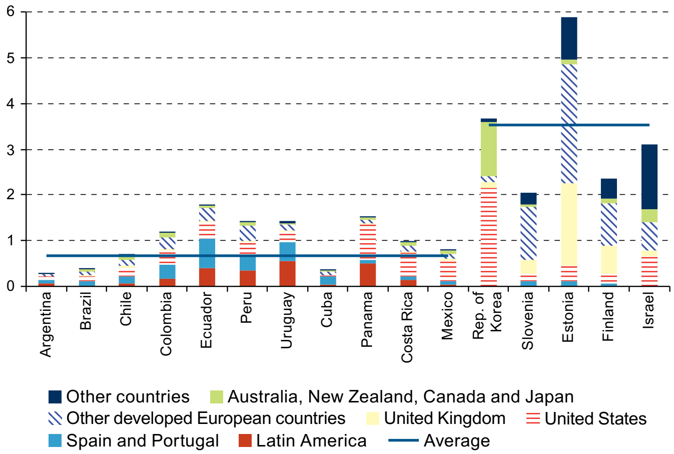
I. Just 0.7% of tertiary education students study abroad

- Countries aspiring to approach the knowledge frontier need to encourage the initial and later training of their scientists at world-class universities.
- Figure IV.10 compares a group of small and medium-sized economies with high investment in R&D (Slovenia, Estonia, Finland, Israel and the Republic of Korea) with a group of Latin American countries. In the countries with high levels of R&D investment, a high percentage of tertiary education students study abroad (3.5% on average). In Estonia, the figure approaches 6%. The main destinations for the students are the United States, the United Kingdom and other developed European countries.
- In the Latin American countries considered, just 0.7% of students do their specialization studies abroad. Within the region there are three groups. The first (Argentina, Brazil and Chile) have low rates of students abroad, and the main destinations are other countries in the region and the United States. The second group consists of the Central American countries and Mexico, which have rates of around 1%, and destinations predominantly in the United States. Lastly, Colombia, Ecuador, Peru and Uruguay have study rates abroad above 1%, the leading destinations being Spain, Portugal and other countries of the region.
- The Latin American countries need to improve their strategies for advanced human capital formation, by increasing the proportion of their students who enter training centres of excellence. This would enable them to increase knowledge of scientific and technological progress and develop networks of contacts for generating innovations.

■ **Figure IV.10** ■

Selected countries: proportion of higher education students studying abroad by destination country, 2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of data from UNESCO Institute for Statistics.

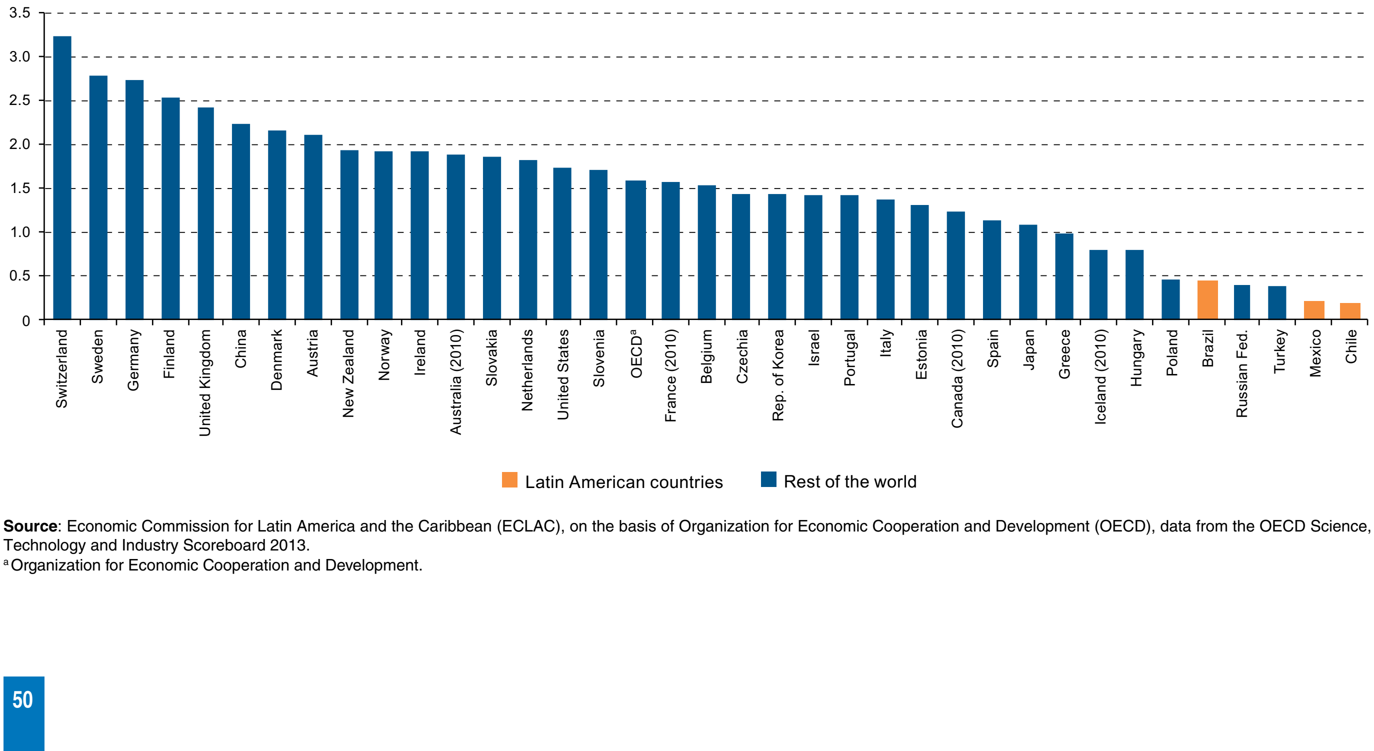
J. Only a tiny fraction of young people pursue doctoral studies

- The shortage of skilled personnel for R&D activities can be inferred from the PhD graduation rate as a percentage of the population in the reference cohort. Even Brazil, Mexico and Chile have very low rates, below 0.5%, much lower than those of the technologically advanced countries.
- This deficit is the result of the low capacities of education systems in Latin America. The coverage of the school system is uneven between the countries of the region and particularly low in the Central American countries. The quality of school education, measured by PISA, displays major lags with respect to the technologically advanced countries. The higher-education enrolment rate is low in most countries, and only Argentina and Chile attain industrialized country levels. In general, higher education students do not have access to universities of excellence. Brazil and, to a lesser extent, Argentina, Chile, Colombia and Mexico, have a few universities ranked among the best in the world. The strategy pursued by countries with high investment rates in R&D that do not have universities of excellence is that their students receive training in countries that are technological and scientific powers. Few Latin Americans study in the industrialized countries, even though several countries in the region have scholarships for this purpose. This pattern of failings in the education system is the cause of the low rate of PhD training and the shortage of research workers.

Figure IV.11

Selected countries: PhD graduation rate, 2011

(Percentage of the population by reference cohort)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Organization for Economic Cooperation and Development (OECD), data from the OECD Science, Technology and Industry Scoreboard 2013.

[a] Organization for Economic Cooperation and Development.

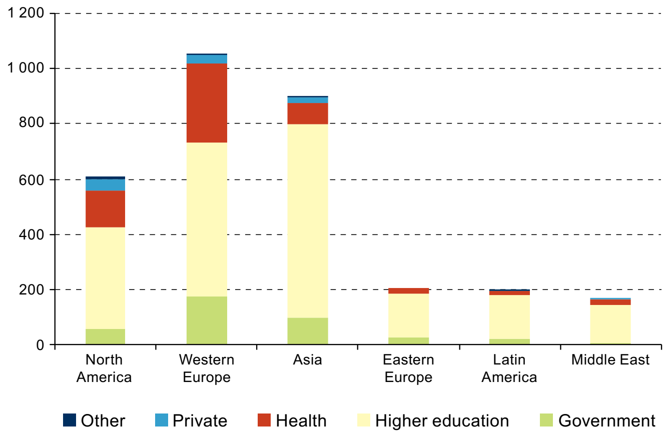
K. The region has few internationally recognized laboratories

- Scientists need workplaces where they can perform the functions for which they were trained, otherwise the investment in advanced human capital will be lost and brain drain will occur: young people who study abroad and do not return to their countries of origin.
- The Scimago Institutions Rankings database contains a classification of scientific institutions that includes medical, State, business and university laboratories around the world, based on information compiled on institutions that have published, in the year prior to the period evaluated, at least 100 scientific documents (articles, reviews, letters or conference papers, among others) indexed in the Elsevier Scopus database. Those institutions (which in 2010 totalled 3,290 worldwide) are analysed according to indicators of scientific output, international collaboration, impact, quality, specialization and scientific leadership of the publications. There were 198 Latin American laboratories in this database in 2010, one third of those corresponding to North America. The Eastern European countries had over 1,000 laboratories in this ranking, whereas the Asian countries had 900, thanks to the contribution of China, India, Japan and the Republic of Korea. In Latin America, as in the rest of the world, most laboratories with scientific publications are part of or affiliated to universities, although in the advanced countries, a significant number of laboratories are also attached to health-care institutions and the government.
- Half (52%) of Latin American laboratories are in Brazil, which has 104. Mexico has a 16% share with 32, followed by Argentina, Chile, Colombia and the Bolivarian Republic of Venezuela. The other countries had very few laboratories that publish a significant number of indexed scientific papers.

■ **Figure IV.12** ■

Regions of the world: laboratories with over 100 scientific publications by region and type of laboratory, 2010

(Number of laboratories)

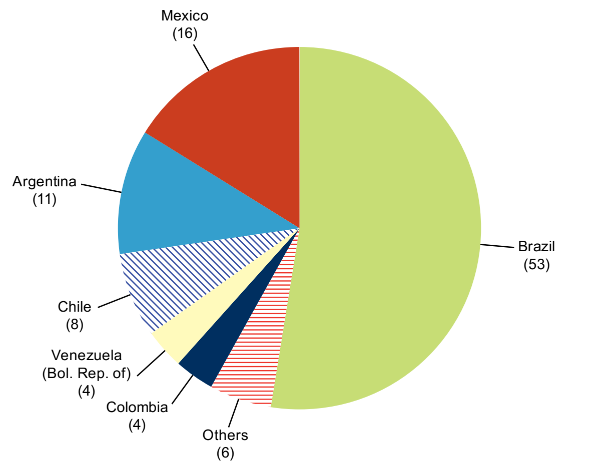


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Scimago Institutions Rankings, "World Report 2012: Global Ranking" [online] https://www.upjs.sk/public/media/7379/sir-2012-world-report.pdf.

■ **Figure IV.13** ■

Latin America: share of laboratories with over 100 scientific publications, 2010

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Scimago Institutions Rankings, "World Report 2012: Global Ranking" [online] https://www.upjs.sk/public/media/7379/sir-2012-world-report.pdf.

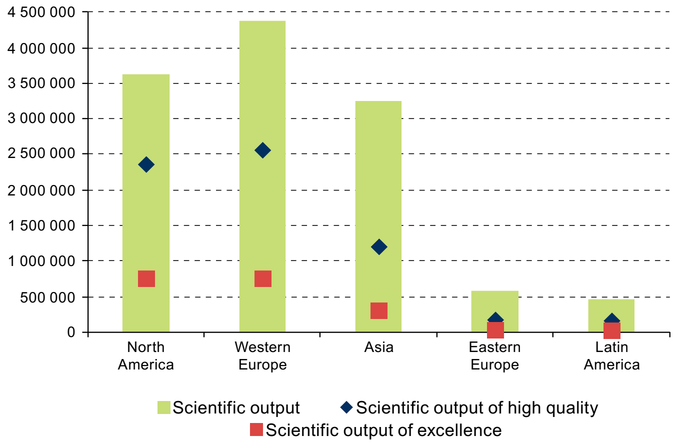
L. Scientific output is very small and its quality does not compete with the advanced countries

- To effectively integrate new scientists into the national innovation ecosystem, there needs to be an adequate number of laboratories with scientific output of a high enough quality to keep them at the forefront and enable them to develop patents or generate findings that lead to innovative products and processes.
- The scientific output of the region's laboratories can be estimated by the number of papers published between 2006 and 2010 in Scopus by institutions compiled in the Scimago Institutions Rankings database. North America surpasses Asia in terms of scientific output, despite having fewer research institutions, while Eastern Europe is the region with the largest number of publications. Latin America has one third of the number of laboratories existing in North America, but they produce less than one seventh of the latter laboratories' output.
- The number of papers published in the world's most influential academic journals, in other words those ranked in the first quartile (top 25%) of their category according to the Scimago Journal Rank classification, serves as a metric of the quality of scientific publications. A large proportion of publications by North America are concentrated in these journals, which brings it close to the level of Eastern Europe, the world leader in publication quality. Latin American publications represent just 2.5% of the articles that appear in the world's top journals.
- A more demanding measure, which considers publications of excellence as those included in the 10% most cited in their respective scientific fields, gives an indication of which regions are at the frontier of world knowledge. By this indicator, North America is ranked first, ahead of Western Europe. In contrast, Latin America's scientific output of excellence is only marginal.
- In conclusion, North America is the global leader in terms of excellence and scientific quality, even though it has fewer research institutions than Western Europe or Asia. The gap between Latin America and the advanced countries —already large when measured by the number of research institutions in each region— grows wider when measured by volume of scientific output and even more so when gauged by quality. This shows that the scarcity of highly specialized human resources in the region has major negative consequences for its scientific and technological production.

■ Figure IV.14 ■

World regions: production of scientific publications 2006-2010

(Number of publications)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Scimago Institutions Rankings, "World Report 2012: Global Ranking" [online] https://www.upjs.sk/public/media/7379/sir-2012-world-report.pdf.

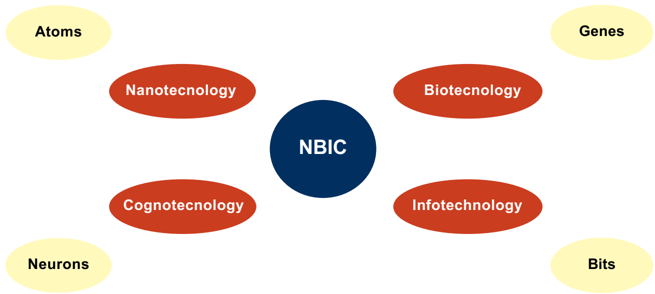
V. The new technologies and the digital revolution: keys for development

A. The new technological revolution revolves around NBIC convergence

- The current technological revolution is based on the capacity to understand the structure and behaviour of the subject, ranging up from its most fundamental elements and smallest scales to their aggregation in complex structures and systems.
- This forms the basis of the scientific-technological platforms of NBIC convergence: nanoscience and nanotechnology, life sciences and biotechnology, information and communications technologies and sciences (ICTs), and cognitive sciences and related technologies.
- The concept of NBIC convergence has now been extended to the convergence of knowledge, technology and society (CKTS), defined as the escalating and transformative interaction among seemingly distinct scientific disciplines, technologies, communities and domains of human activity to achieve mutual compatibility, synergism, and integration, and through this process to create added value and diversify.
- CKTS is important for achieving the Sustainable Development Goals given its effect on human health, communication and knowledge, productivity and social progress, education and physical infrastructure, society and sustainability, and the possibility of attaining innovative and responsible social governance. For example, interactions between the human-scale platforms (local food systems), the earth-scale platform (water and nitrogen cycles, climate) and the NBIC scale (genetic enhancement, phenological monitoring) will have significant implications for the fight against hunger.

■ **Diagram V.1** ■

Convergence of technological paths



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

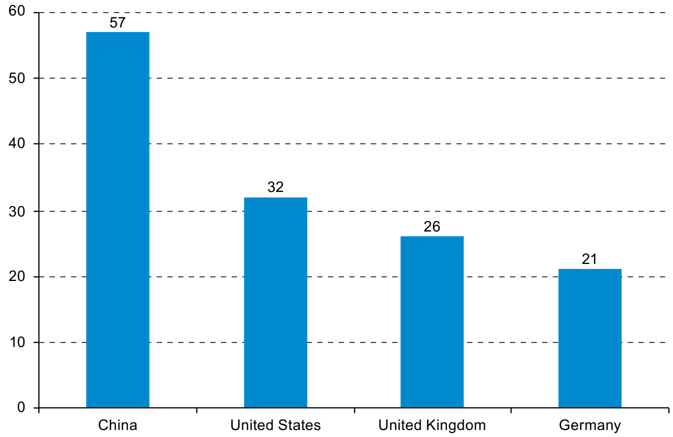
B. The universalization of the digital economy and resurgence of manufacturing

- In the advanced manufacturing of the twenty-first century, the digital and physical worlds are converging: advanced hardware is combined with advanced software, sensors and big data analytics, and this results in smart products and processes, with greater interaction between consumers, suppliers and manufacturers.
- The most significant change in the economy is occurring in business models based on the connectivity of objects, or the Internet of Things, with the greatest advances emerging in health (monitoring applications, medication dispensers and tele-medicine) and in manufacturing (robotization, advanced manufacturing and the development of next-generation machine-to-machine (M2M) services), as well as in areas such as energy, transport, natural resources and smart electricity grids. The resulting rapid changes in consumption and production patterns are challenging Latin America, for which the production of new technologies is largely exogenous.
- The Internet of Things is having disruptive effects in all sectors. The boundaries between industries and markets are changing rapidly as smart, connected products emerge and cyber-physical production systems are created.
- Manufacturing will have a newly valuable role to play in combination with digital services: advanced manufacturing is revolutionizing the sector by enhancing its knowledge content, flexibility and competitive potential.
- To that end, world leaders have boosted their industrial and technology policies, as revealed in the strategies for greater industrial development applied recently: such as Industrie 4.0 (in Germany), Advanced Manufacturing (in the United States), and Made in China 2025.
- Although the Industrie 4.0 (in Germany) or Advanced Manufacturing strategies enable significant competitiveness gains for the manufacturing sector, the potential benefit to be obtained will depend on how prepared the countries are for adopting them. Here, China would seem to have an advantage over its closest competitors (Germany, the United States and United Kingdom).

■ **Figure V.1** ■

Selected countries: maturity in implementing the Industry 4.0 strategy

(Percentages of interviewees who believe their country is prepared for early adoption of the Industry 4.0 strategy)



Source: Infosys [online] www.infosys.com.

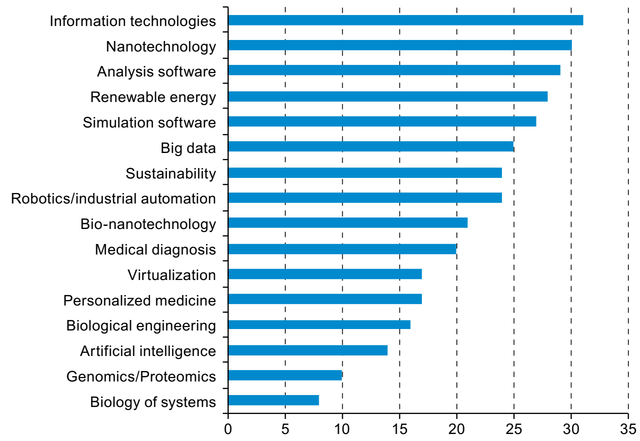
C. The Internet of Things and the resurgence of manufacturing will require a stronger commitment to innovation

- In many industries, investment in R&D is essential for the development of new products and for competitiveness; accordingly, vast sums are spent in that area and on related activities.
- Globally, six sectors account for over 50% of the total amount invested in R&D: digital technologies, life sciences (including the pharmaceutical, biotechnology and medical instruments sectors), chemicals and new materials, aerospace technology and defence, automobiles and the transport system, and the energy system. All of these are very active in innovation.
- Given the spread of advanced manufacturing and the Internet of Things, over the last few years these sectors have undergone major changes, both in the technologies they use and develop and also in market concentration.
- Some of the most important changes linked to technological progress relate to the continuity of the digital and nano-technologies revolution (figure V.1 identifies the main technologies that will be important in 2018, according to specialist surveys).

■ **Figure V.2** ■

Key technologies envisaged, 2018

(Importance percentages allocated by the researchers interviewed)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Industrial Research Institute.

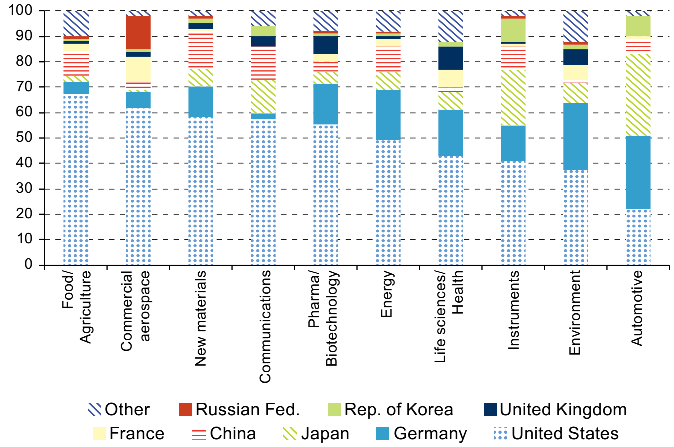
D. Despite China's progress, the United States continue to lead the new technologies

- Over the past 20 years, the number of researchers and the amount of R&D investment worldwide has grown exponentially. This has enabled major progress in terms of capacities and the generation of new knowledge, technologies and innovations.
- In this context, new protagonists have emerged in the different types of technology. An example is China in the areas of new materials, communications and energy, which, although they still represent a small share of the total, have grown very vigorously.
- Nonetheless, the United States still invests most in nearly all technologies. In particular, it accounts for over 50% of R&D on food, aerospace technology, new materials, communications, and pharmaceuticals and biotechnology. It also leads in many other technological areas, except for the automotive industry, which is dominated by Japan and Germany.

Figure V.3

Leading countries in selected technology sectors: distribution of global investment in R&D by technology sector, 2014

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from Industrial Research Institute, 2016.

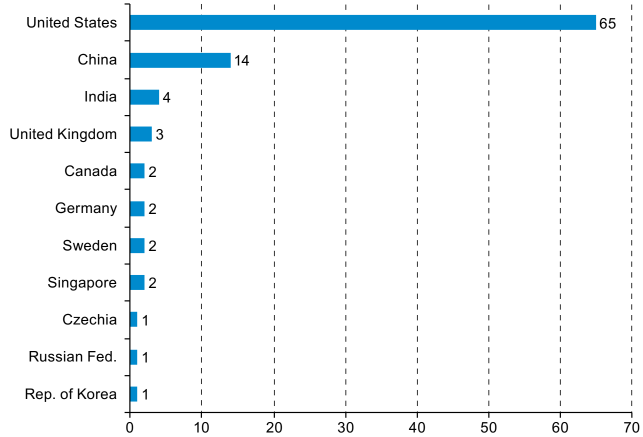
E. The universal spread of digitization has allowed for the emergence of “unicorns” in the digital industry, which are changing the global economic and social panorama

- New technology-based start-ups have the potential to contribute to structural change and to the generation of knowledge-intensive activities. Nowadays, the term “unicorn” is used in the digital industry to refer to technological enterprises valued at over US$ 1 billion; the many examples of this type of initiative include cases such as Facebook, Uber and Spotify.
- The United States lead this industry, accounting for 65% of this type of firm; and it is followed in importance by China, India, the United Kingdom, Singapore, Sweden, Germany, Canada, the Republic of Korea, the Russian Federation, and Czechia. Jointly, these countries account for 97% of start-ups.
- The same indicator by city clearly reveals the concentration of technology clusters. In the United States, Silicon Valley heads the list (39%); and it is followed by New York (9%), Los Angeles (5%), Boston (4%), Provo (2%) Chicago (1%) and Jacksonville (1%). Other technology-important cities around the world include Beijing (6%), Shanghai (China) (3%), London (2%), Singapore (2%), Stockholm (2%), Berlin (2%), Hangzhou (China) (2%), New Delhi (1.7%), Seoul (1.5%), Shenzen and Hong Kong (China) (1.4%), Bombay (India) (1.4%), Canton (China) (1.1%), Bangalore (India) (1.1%), Moscow (1%) and Prague (1%).
- Although country size is closely related to the value of technological enterprise, it is not the whole explanation, because some smaller countries, such as Sweden and Singapore, also play a leading role.
- The “unicorns”, which are changing the way the world relates in all of its dimensions (social, economic and political), are fundamental factors that need to be taken into account in the countries development strategies.

Figure V.4

Selected countries: ranking of the share of technology-based enterprises valued at over US$ 1 billion, 2014-2015

(Percentage of the total number of firms)

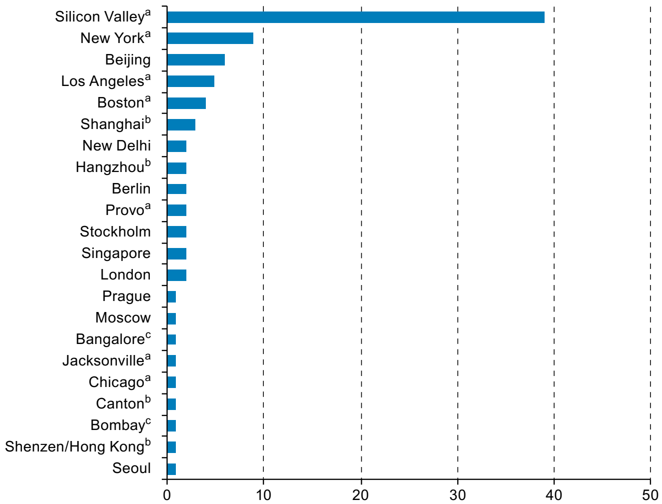


Source: G. Tellis, “2016 Startup Index of Nations, Cities: (Startups Worth $1 Billion or More: “Unicorns”)”, 2016 [online] https://www.marshall.usc.edu/sites/default/files/PDF/Unicorn-Index-Report-GT17.pdf.

Figure V.5

Selected cities: ranking of the share of technology-based enterprises valued at over US$ 1 billion, 2014-2015

(Percentages of the total number of firms)



Source: G. Tellis, “2016 Startup Index of Nations, Cities: (Startups Worth $1 Billion Or More: “Unicorns”)”, 2016 [online] https://www.marshall.usc.edu/sites/default/files/PDF/Unicorn-Index-Report-GT17.pdf.

[a] United States.

[b] China.

[c] India.

F. The new technologies require the development of new capabilities

- The world is in the midst of a new technological revolution driven by mobile Internet and cloud computing, big data analytics, the Internet of Things, robotics, artificial intelligence, machine learning, advanced manufacturing, and 3-D printing. These technologies open up opportunities for innovation in the provision of services and business models, by giving rise to new production processes, value chains and industrial organization models (ECLAC, 2015).
- The spread of digitization is transforming economic, political, institutional and social structures worldwide faster than in previous industrial revolutions. This implies opportunities and challenges, particularly in relation to medium and long-term employment.
- In a context where artificial intelligence is evolving from algorithm-based programming to pattern recognition, the spaces reserved for human work are being occupied by robots, or mainly by collaborating robots (cobots).
- In practice, not all workers will have to compete with machines; some will need to learn to work in close collaboration with machines that are intelligently connected to cyber-physical systems.
- This transformation has given rise to new production and consumption models: the zero marginal cost economy, the industrial Internet and the sharing economy. These models have major implications in terms of capability and employment requirements.

Table V.1

The new industrial revolution and the employment context

Consumption and production patterns	Characteristics	Implications in employment	New capabilities needed
Zero marginal cost in the digital economy	• New Internet-based business models for of production, distribution of digital goods and services • Low marginal cost of distribution and production • Co-production by firms and consumers	• Robots and machine learning to replace labour	• New jobs that require new knowledge and capabilities • New capabilities in the field of software development and data analysis
Industrial Internet	New industrial and production models that use: • Machines and sensors connected through the Internet • Robots and machine learning • Cyber-physical systems	• Replacement of jobs involving routine and repetitive tasks • New production capacities that require digital and industrial capabilities, data analysis, R&D, technicians and specialists to create and manage advanced and automated production systems, solution architects, industrial data scientists, advanced manufacturing engineers	• Cognitive capacities, resolution of complex problems and data analysis, social skills, critical thinking, literacy and active learning
Gig economy	• Business models that make frequent use of temporary contracts and self-employment on short-term tasks	• Jobs that are not adapted to the existing legal definitions on employment and the status of self-employed contractor	• Basic digital skills

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

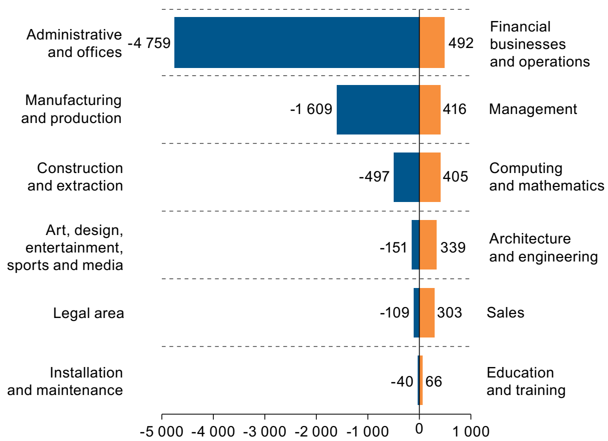
G. Job creation will be an additional concern for the region

- Given current trends and recent projections, technological change in the most developed countries is expected to cause the loss of over 5.1 million jobs in 2015-2020. This figure represents the difference between a total loss of 7.1 million jobs —mainly in office and administrative tasks— and a total gain of 2 million jobs (WEF, 2016).
- Bearing in mind current production structures, the sectors in which employment will grow (commercial and financial operations, administration, information technology and mathematics) are likely to create far fewer jobs than those that will be lost in areas affected by technological change (office and administrative jobs, manufacturing and production). These results are likely to impact the middle class and women in particular, given their large share of office jobs.
- On average, in 2020 over one third of the basic skills needed in most jobs will consist of those that are not yet considered crucial for today's work. To successfully manage these trends, the countries need to apply policies aimed at reskilling, and upgrading qualifications and capacities. Without urgent and specific action to manage the short-term transition and shape a labour force that matches the future demand for skills, governments are bound to face rising unemployment and inequality, and firms will find their consumer base shrinking.
- This scenario is particularly difficult for developing countries, where the greatest population growth will occur. These countries lack the skills needed for the new tasks, and their institutional framework is unsuited to providing a rapid response. Basic and secondary education alone is not a solution, because it is unlikely to solve skill shortages among the generation currently entering the labour market.
- Thus, developing countries are likely to face youth unemployment simultaneously with a shortage of labour in areas related to the new technologies. This is particularly significant in Latin America and the Caribbean, where 36% of firms are already finding the labour force's inadequate education level a major operational obstacle. This figure is more than double that of the countries of the Organization for Economic Cooperation and Development (OECD) (15%); and it is well above the world average of 21% (CAF, ECLAC/OECD, 2014).
- Latin America and the Caribbean faces a very particular situation with regard to youth job creation in the context of the technological revolution. In 2019, the region will have a shortage of over 449,000 professionals in digital technologies (IDC, 2016).

■ **Figure V.6** ■

Net job creation by type of job, 2015-2020

(Thousands of jobs)



Source: World Economic Forum (WEF), *The Future of Jobs*, 2016.

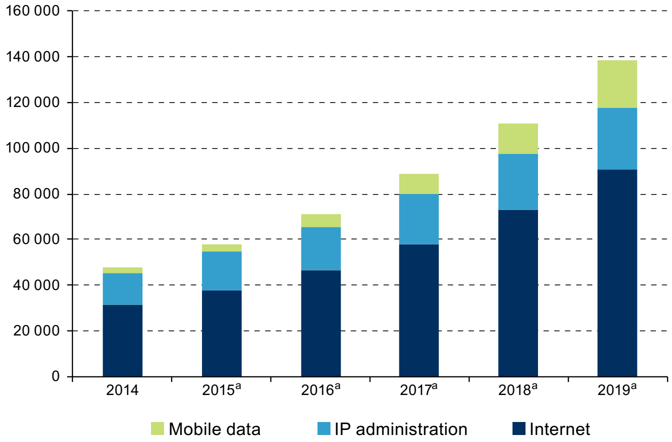
H. The countries urgently need to address the disruptive effects of the digital economy

- The large-scale dissemination of digital technologies and complex systems that combine hardware, sensors, data storage, microprocessors and software is forging a new industrial era, changing the nature of products, altering value chains and forcing firms to redesign their strategies to adapt to the digital economy.
- Cisco (2015) estimates that, between 2014 and 2019, IP data traffic volumes will grow at a rate of 24% per year, but the mobile growth rate will be 59%. Thus, Internet activity will be increasingly intense: by 2020, bandwidth speed will double, the number of devices connected to IP networks will be three times the world's population, and the total number of smart phones will represent almost 50% of global devices and connections.
- This context presents new competition scenarios for firms, and offers them huge opportunities to increase innovation and productivity. The hallmark of this new era of technological change is the capacity to integrate physical products with smart components (sensors, microprocessors, controls, software and others) and connectivity, so that they can in turn become part of new product systems. These changes affect nearly all industries, directly or indirectly, and the global economy as a whole. To fully capitalize on the benefits of these technologies, firms and governments must work together on issues such as skill development, the establishment of rules and regulations needed to allow innovation and the definition of standards.

Figure V.7

Global consumer IP data traffic, by type of connection, 2014-2019

(Petabytes per month)



Source: Cisco, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020 White Paper*, 2015.
[a] Estimates.

I. Access to digital technologies and the use of global platforms have expanded enormously in Latin America and the Caribbean

- The penetration of digital technologies in the region over the last few years has been astonishing. In the case of mobile telephony, the figures exceed 100%, and over 50% of the region's population are Internet users. Moreover, annual average growth in the penetration of mobile broadband subscriptions is 154%, which represents about 60% of the population.
- Latin American Internet users also make intensive use of social networks, displaying higher rates than in the United States and Europe.
- Nonetheless, the type of digital platforms used in the region are mainly foreign websites, which reveals a lack of participation by national regional firms in this part of the industry value chain. In terms of content, the most popular local sites are multimedia portals and e-commerce sites.

■ Table V.2 ■

Social network subscribers, 2013

(Number of persons and percentage of Internet users)

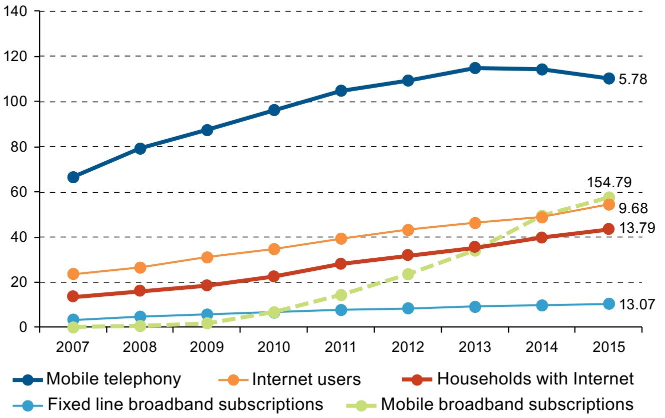
Region	Number of social network subscribers	Social network subscribers *(percentage of Internet users)*
Western Europe	178 490 451	54.47
Eastern Europe	82 286 947	70.89
North America	192 685 415	64.64
Latin America	223 174 613	78.42
Asia and the Pacific	891 194 019	73.19
Commonwealth of Independent States (CIS) and Russian Federation	46 020 576	32.23
Sub-Saharan Africa	37 118 175	25.64
Middle East and North Africa	64 898 306	38.59
World	1 715 868 503	63.55

Source: Telecom Advisory Services (TAS), on the basis of Internet World Stats.

■ Figure V.8 ■

Latin America and the Caribbean: information and communication technology (ICT) penetration rates, 2007-2015

(Percentages of the population and cumulative growth rates)

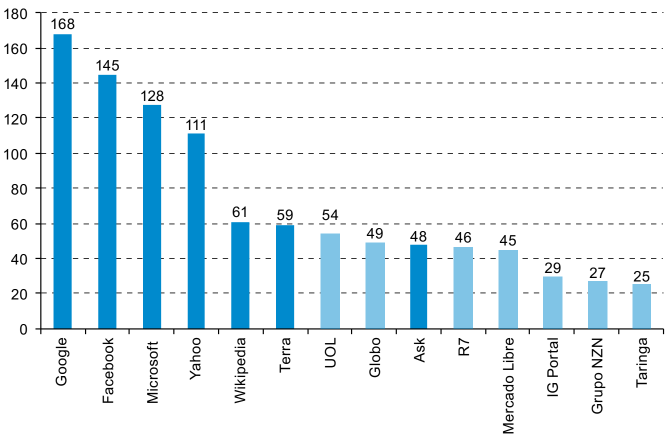


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Telecommunication Union (ITU), World Telecommunications Indicators Database, 2016.

■ Figure V.9 ■

Latin America: most popular Internet sites

(Number of individual hits per month)



Source: Telecom Advisory Services (TAS), on the basis of ComScore.

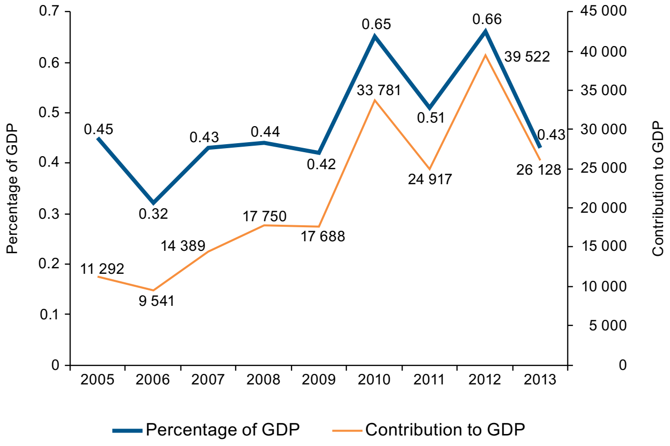
J. The economic impact of digitization in Latin America and the Caribbean has contributed 4.3% of GDP in eight years

- Various studies have confirmed the positive economic impact of digital technologies on growth and employment. Based on an endogenous growth model that relates GDP to a country's level of digitization, the available estimates show that between 2005 and 2013 the economic impact of this process in Latin America and the Caribbean has contributed 4.3% of cumulative GDP growth, equivalent to US$ 195 billion.
- In the case of employment, the deployment and assimilation of digitization is estimated to have a much greater impact, because they contribute not only to job creation in the ICT sector (for example, software development, hardware manufacture and supply of parts), but they also have indirect effects on other sectors of the economy, such as commerce, financial services and health. In this case, digitization is estimated to have created 900,000 jobs per year in the region. It is important to note that these effects increase with the maturity of the country's digital ecosystem, including such factors as the accessibility of ICTs, infrastructure quality, network access and its use, and skilled human capital.
- Given the global technological dynamic, a country's competitiveness and growth will increasingly depend on its integration into the global digital ecosystem. This will force countries to improve their infrastructure, human capital and business climate, define global standards, regulate data flows, protect intellectual property rights and safeguard user security and privacy. These issues should be addressed from a regional perspective to promote the formation of a digital common market in Latin America and the Caribbean, which would substantively support the expansion of the digital economy (ECLAC, 2015).

Figure V.10

Latin America and the Caribbean (22 countries)[a]: economic impact of digitization 2005-2013

(Percentages of GDP and millions of dollars)



Source: Telecom Advisory Services (TAS), *The Ecosystem and Digital Economy in Latin America*, 2015.

[a] Includes Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and the Plurinational State of Bolivia.

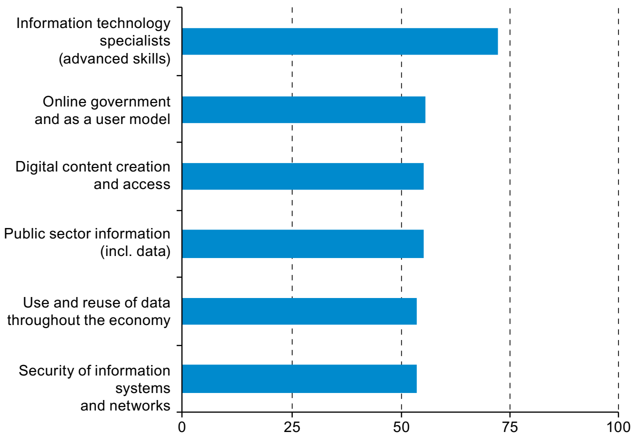
K. Improving technology appropriation requires moving towards more complex digital agendas that include other challenges

- The validity of national policies on digital issues in Latin America and the Caribbean is clear to see. Table V.3 shows that 17 out of 23 of the region's countries (73%) have a digital agenda already implemented or under development. Chile, Colombia and Uruguay are actually implementing third and fourth generation national ICT plans.
- Access, infrastructure and broadband deployment remain priorities on digital agendas, along with other common objectives such as promotion of the ICT industry, capacity-building, content development, e-government and education. A recent OECD study of the priority trends of ICT policies in 31 countries shows that the main challenge for the next few years is the development of digital skills, followed by the improvement of online public services, content creation, and the use and reuse of data, issues which need to be built into the agendas so that work on them can be started.

Figure V.11

Priority trends of ICT policies, 2014[a]

(Percentages)



Source: Organization for Economic Cooperation and Development (OECD), *Digital Economy Outlook 2015*, Paris, 2015, on the basis of an OECD questionnaire on current and future policy priorities, June 2014.

[a] The ICT policy areas have been selected and ranked according to the priority indicated.

Table V.3

Latin America and the Caribbean (23 countries): status of national digital agendas,[a] 2016

Country	National digital agenda
Argentina	In development
Barbados	Implemented
Bolivia (Plurinational State of)	Needs to be created or reformed
Brazil	Needs to be created or reformed
Chile	Implemented
Colombia	Implemented
Costa Rica	Implemented
Cuba	Implemented
Dominican Republic	In development
Ecuador	Implemented
El Salvador	Need to be created or reformed
Guatemala	In preparation
Haiti	Needs to be created or reformed
Honduras	Implemented
Jamaica	Implemented
Mexico	Implemented
Nicaragua	Needs to be created or reformed
Panama	Implemented
Paraguay	Implemented
Peru	In development
Trinidad and Tobago	Needs to be created or reformed
Uruguay	In development
Venezuela (Bolivarian Republic of)	Implemented

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

[a] The national digital agenda is defined as the country's set of sectoral ICT strategies; in other words, the set of digital policies that maintain a minimum degree of mutual consistency and articulation across the country.

L. Better policy tools are needed to promote technological entrepreneurship

- Although very few countries have succeeded in developing technology start-ups, there is room for the region to make progress with technological enterprises. The Latin American countries have adopted different strategies to promote them, yet this type of initiative still faces a number of challenges relating to the lack of financing, shortfalls in technological capabilities and knowledge, business management capacities and the lack of appropriate institutions. In this framework, policies can offer a series of incentives and conditions for their development through instruments that include the provision of financing, advice and training, and the promotion of a business-friendly legal framework.
- A 2013 analysis by OECD found that Brazil and Chile offer the widest range of financial support mechanisms through all the stages of development. In contrast, Mexico still has much to do to help start-up businesses, while Argentina needs to improve its support during the expansion stage. Colombia and Peru are creating mechanisms to support seed capital.
- In the case of business support and capacity-building programmes, most countries have incubators, except Peru. Moreover, incentives to speed up projects are either under development or do not yet exist. Argentina, Brazil, Chile and Mexico have implemented or are preparing technology and capacity transfer schemes; Colombia and Peru need to boost their efforts in this field. Several countries do not have a regulatory framework to promote enterprise, nor have they established specific tax incentives. In other cases, these areas need reform.

Table V.4

Latin America: specific policy tools to promote start-ups, 2012

Instrument		Argentina	Brazil	Chile	Colombia	Mexico	Peru
Financing	Seed capital	In development	Implemented	Implemented	Recently created	Need to be created or reformed	Recently created
	Angel investors	Need to be created or reformed	Implemented	In development	Recently created	Need to be created or reformed	Need to be created or reformed
	Venture capital	Need to be created or reformed	Implemented	Implemented	Recently created	In development	Need to be created or reformed
Business services and entrepreneurial training	Incubators	Implemented	Implemented	Implemented	In development	In development	Recently created
	Accelerators	In development	In development	In development	Need to be created or reformed	In development	Need to be created or reformed
	Corporate spin-offs	Need to be created or reformed	Need to be created or reformed	Need to be created or reformed	Need to be created or reformed	Need to be created or reformed	Need to be created or reformed
	Technology transfer	In development	Implemented	In development	Need to be created or reformed	Implemented	Need to be created or reformed
	Business training	Implemented	Implemented	Implemented	In development	In development	In development
Regulatory framework	Ease of creating or closing down businesses	Need to be created or reformed	Need to be created or reformed	In development	In development	In development	In development
	Taxation and special legislation	Need to be created or reformed	In development	In development	Need to be created or reformed	In development	Need to be created or reformed

Source: Organization for Economic Cooperation and Development (OECD), *Start-up Latin America: Promoting Innovation in the Region*, 2013.

M. There is plenty of room for e-commerce growth in Latin America

- Official statistics on e-commerce are few and far between, but the available information suggests that a large number of firms in the region have an Internet presence and engage in online commercial transactions. For example, in Brazil it is estimated that 62% of firms have their own website and 21% conduct online sales. Forecasts by private consultants see the retail e-commerce market growing steadily in Latin America in the next few years, with a sales volume projected at close to US$ 50 billion for 2016 and a compound annual growth rate of 19%. Argentina, Brazil and Mexico are the main e-commerce markets in the region, accounting for about 73% of sales.
- Latin America has plenty of room to promote the growth of this market. The proportion of e-commerce retail sales represent just 2.6% of total retail sales in the region, a much smaller share than in other regions such as North America (8%), Western Europe (8%) and Asia and the Pacific (12%).

Table V.5

Latin America (selected countries): enterprise websites and Internet sales[a]

(Percentages)

Country/indicator	Brazil, 2014	Costa Rica, 2013	Colombia, 2014	Chile, 2015	Dominican Republic, 2013
Proportion of firms with their own website	62.0	70.5	66.4	34.1	56.3
Proportion of firms that receive Internet orders	21.0	70.5	69.8	23.7	34.0

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Brazil, Regional Centre for Studies on the Development of the Information Society (Cetic.br), for ICT, homes and enterprises, 2015; Costa Rica: Ministry of Science and Technology /Centro Internacional de Política Económica para el Desarrollo Sostenible (CINPE)/Universidad Nacional, Encuesta Nacional de Ciencia, Tecnología e Innovación a Empresas; Colombia: National Administrative Department of Statistics (DANE), Encuesta Anual Manufacturera; Chile: National Statistical Institute (INE), Encuesta Longitudinal de Empresas; Dominican Republic: National tatistical Office (ONE), Encuesta Nacional de Actividad Económica.

[a] Figures refer to firms with more than 10 employees.

Table V.6

Latin America, estimates of retail e-commerce, 2016[a]

Country	Sales value *(billions of dollars)*	Compound annual growth rate *(percentages)*	E-commerce *(percentages of retail trade)*
Brazil	22.12	12.0	3.6
Mexico	7.24	25.0	2.3
Argentina	6.85	28.0	1.7
Others	13.63	23.0	2.3
Latin America	49.83	19.0	2.6

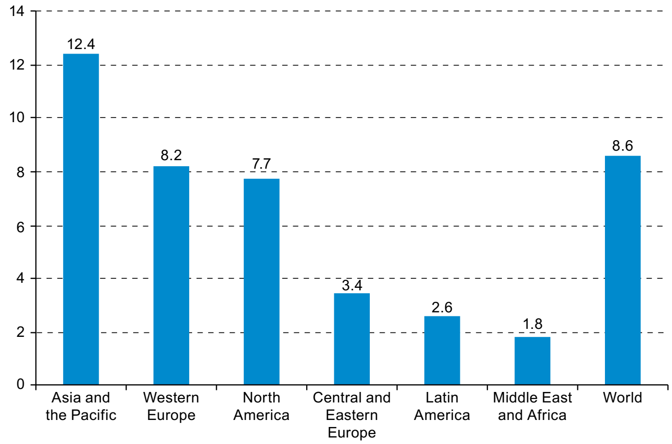
Source: eMarketer, *Worldwide Retail Ecommerce Sales: Emarketer's Updated Estimates and Forecast Through 2019*, 2015.

[a] The estimates are based on the analysis of data from other research firms and government entities, historical trends, the reported and estimated income of large-scale online retailers, the online purchasing trends of consumers, and macroeconomic conditions. The data include products and services acquired and the invoicing of business travel reserved over the Internet through any medium, irrespective of the means of payment or settlement.

Figure V.12

Retail e-commerce sales, 2016[a]

(Percentages of global total)



Source: eMarketer, *Worldwide Retail Ecommerce Sales: Emarketer's Updated Estimates and Forecast Through 2019*, 2015.

[a] The figures include products or services ordered over the Internet from any device, without considering the payment method; does not include travel or tickets to events.

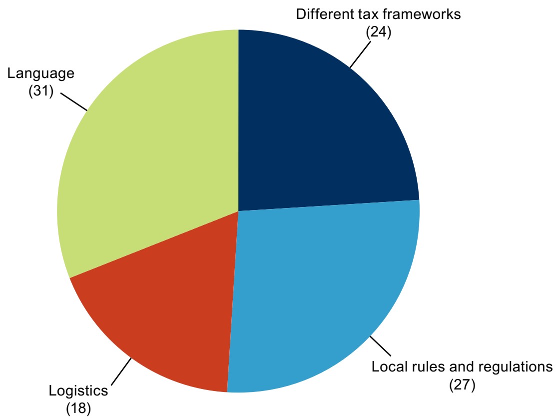
N. Further development of the digital economy requires an integrated digital market

- Use of the Internet facilitates trade, but there are a number of factors that affect its expansion. A recent survey performed by Keira McDermott and Payvision (2015) of traders, providers of commercial services, providers of payment services and consultants, identified tax, normative, regulatory, logistics and language aspects as the main barriers to the development of cross-border e-commerce. The need to comply with different tax and legal frameworks can discourage firms from expanding their online services.
- Moreover, the different consumer laws that govern procedures for resolving complaints and product returns can differ from one country to another, making it complex to resolve disputes between buyers and sellers.
- Privacy and data protection regulations can also hinder the exchange of data between regions and the development of business models that make intensive use of personal data.
- In addition, the different tax and tariff burdens between countries can affect the levels of competition of certain goods and services that are bought over the Internet. Lastly, although language can be a barrier, in the case of Latin America it can represent a significant comparative advantage for regional firms.
- In this framework, it is urgent to analyse the opportunities and challenges that can arise from the promotion of a regionally integrated digital market, which lowers the barriers to the free flow of goods and services online and promotes the development of the digital economy, formed by the telecommunications infrastructure, ICT industries (software, hardware and services) and the Internet-enabled network of economic and social activities, thus promoting innovation, productivity and growth.

■ **Figure V.13** ■

Main barriers to cross-border e-commerce worldwide

(Percentages of persons surveyed)



Source: K. McDermott and Payvision, *Key Business Drivers and Opportunities in Cross-Border Ecommerce*, 2015 [online] http://hollandfintech.com/wp-content/uploads/2015/11/key-business-drivers-and-opportunities-2015.pdf.

VI. Science, technology and innovation in agriculture

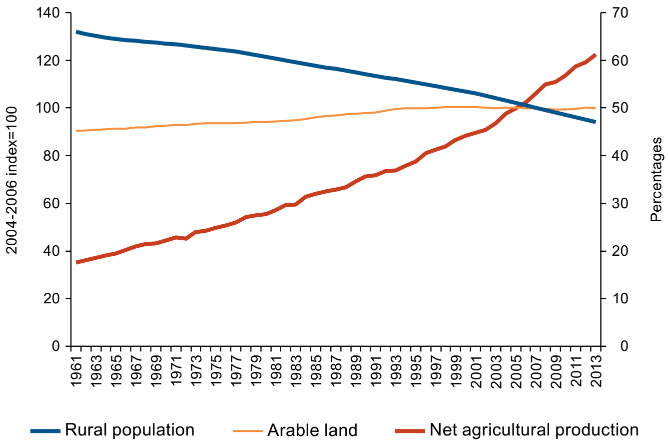
A. Innovation-driven growth in agricultural productivity is essential for structural change and economic development

- Economic development is characterized by the reallocation of resources from the agricultural sector to other sectors, in a process known as structural change. This process is related to productivity gains in agriculture, which free up labour for other activities. Better-paying jobs in non-farm sectors is another important factor driving structural change. However, given the strategic nature of food production, the transfer of labour from agriculture to other sectors tends to occur only when the food supply is secure, whether by means of domestic production or imports.
- Over the past half century, demand for food has increased continually owing to both demographic growth and changes in the intensity and types of consumption. The global food supply has grown faster than demand, so prices have been falling since the 1950s at least. The increase in supply has been achieved through a relatively minor expansion in the agricultural frontier and a significant reduction in the percentage of people living in rural areas.
- Rising production would not have been possible without the agricultural innovations of the last century. Productivity gains have sustained the rates of growth in supply and freed up the labour force for other sectors. Greater access to food has improved life expectancy, boosted labour productivity and increased the rate of population growth. To a greater or lesser extent, at various points in time, this process has taken place both in developed countries and in developing countries with less advanced economies.
- In Latin America and the Caribbean, agricultural productivity, measured as total factor productivity (TFP), underpinned the bulk of the growth seen in agricultural output between 1980 and 2012. Regional agricultural output grew at an average annual rate of 2.1%, with 1.2% attributable to the increase in TFP and 0.9% to greater usage of inputs per worker. Since 2000, regional agricultural productivity has increased more sharply than in the member countries of the Organization for Economic Cooperation and Development (OECD), and as a result the productivity gap with those countries has narrowed. However, regional TFP, as a simple average, is less than 60% of the TFP of the OECD countries.

■ **Figure VI.1** ■

Global net agricultural production, arable land and rural population as a share of total population, 1961-2013

(Index: 2004-2006=100 and percentages of total)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Food and Agriculture Organization of the United Nations (FAO), FAOSTAT database [online] www.faostat.fao.org and World Bank.

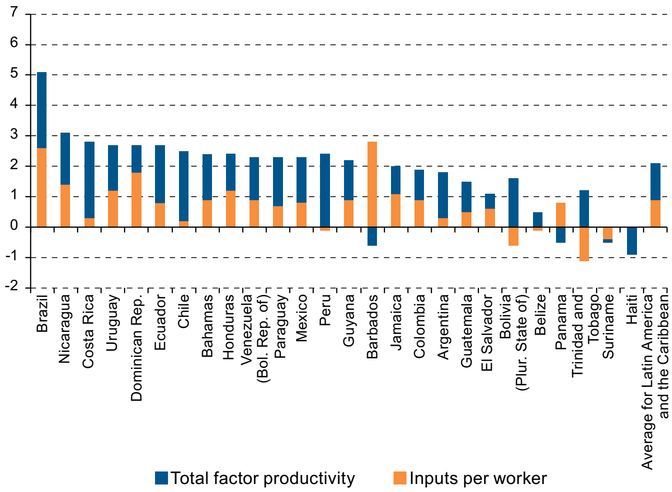
B. Agricultural productivity in the region's countries, especially Brazil, has increased dramatically due to technological advances and efficiency gains

- Brazil led Latin America and the Caribbean in growth in agricultural production between 1980 and 2012 (5.1% per year), with input usage accounting for slightly more of this growth than TFP. In the other countries in the region that posted annual TFP growth of over 2% during the period under review —Chile, Costa Rica and Peru— there was virtually no difference in input intensity.
- Figure VI.3 shows the contribution of two components to TFP in the countries of Latin America and the Caribbean between 1981 and 2012: technological progress and efficiency. The contribution of the first, understood as overall TFP growth, drove three quarters of the increase in regional TFP. This demonstrates the general importance of technology for productivity growth in Latin America and the Caribbean, by contrast to efficiency gains, which accounted for one quarter of the increase in TFP across the region. However, the contribution to TFP of these components varies significantly within the region. In general, the countries with the strongest TFP growth in 1981-2012, represented at the far left side of the figure, were also more efficient.

Figure VI.2

Latin America and the Caribbean (selected countries): components of the agricultural production growth rate, 1980-2012

(Percentages)

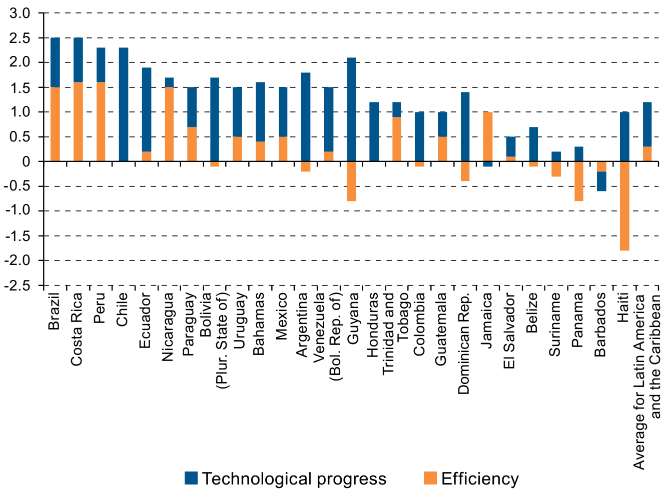


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of A. Nin-Pratt and others, "Productivity and the performance of agriculture in Latin America and the Caribbean: from the lost decade to the commodity boom", *Working Paper Series*, No. 608, Inter-American Development Bank (IDB).

Figure VI.3

Latin America and the Caribbean (selected countries): components of the growth rate of total factor productivity, 1981-2012

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of A. Nin-Pratt and others, "Productivity and the performance of agriculture in Latin America and the Caribbean: from the lost decade to the commodity boom", *Working Paper Series*, No. 608, Inter-American Development Bank (IDB).

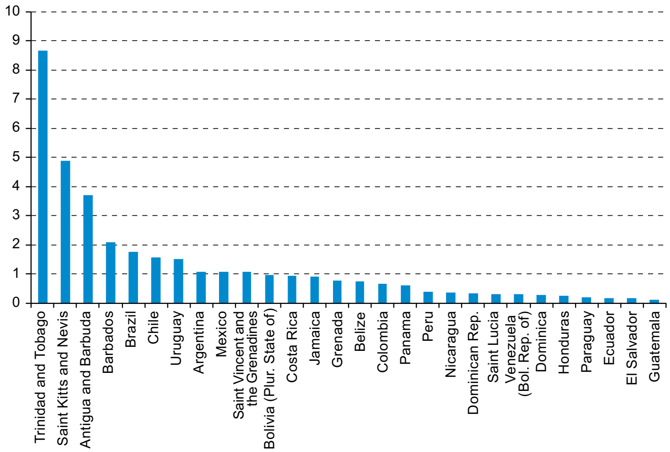
C. Innovation within the countries has driven the increase in agricultural productivity in the region

- Several countries in the humid tropics, the predominant agro-ecological zone in Latin America and the Caribbean, are among those posting the highest TFP growth in the region. Instead of relying solely on international technological advances to boost productivity, these countries have worked to build their own internal capacity and partnered with other similar countries to innovate in line with their contexts and needs. Even in agro-ecological zones where international advances have been particularly beneficial in advancing agricultural innovation, adaptations and extension services are typically needed to bring technology out of the laboratory and to the farmer. Therefore, the region's agricultural productivity gains are, to a greater or lesser extent, the result of internal innovation efforts drawing on local, regional and international innovation systems and networks.
- Investment in agricultural research and development (R&D), researcher training and institutional collaboration are strategies that the region's countries have pursued to improve productivity and efficiency in the farm sector. Over the past 30 years, spending on agricultural R&D in Latin America and the Caribbean has expanded from US$ 3 billion to US$ 5 billion, an average annual increase of 1.7% per year. The number of agricultural researchers in the region grew from 12,000 to over 20,000 in the same period. In both cases, most of the growth occurred after 2004.
- Regional average spending on agricultural R&D in the period under review (2000-2012) was 1.3% of sector GDP. In the developed countries, the intensity of agricultural R&D was 3% of GDP in the 2000s when public spending alone is considered and nearly 6% when both public and private spending are considered (Pardey and others, 2015). A number of countries in the Caribbean have high rates of R&D intensity owing to scale: although the agricultural sector is not very large in these economies, research is nevertheless required to achieve efficiency and security, with the result that spending on this item, as a percentage of national production, is significant. The countries of the Southern Cone of Latin America have R&D rates ranging from 1.0% to 1.7%; rates elsewhere in the region are below 1%. Regional R&D spending is concentrated in a handful of countries: Brazil, which account for over 60% in 2012, followed by Argentina, Mexico, Colombia and Chile. These five countries accounted for 92% of regional spending on agricultural R&D, a higher rate than this group's share of sector GDP, which was 74% in 2012.
- The intensity of agricultural R&D can be measured by the number of researchers for every 100,000 farmers. Argentina leads the region, with nearly 300 researchers for every 100,000 farmers, followed by Barbados, Uruguay, Trinidad and Tobago and Antigua and Barbuda. Once more, the high level of this indicator in the Caribbean countries can be explained by the small size of their agriculture sectors, which nevertheless require a certain scale of R&D. In this area, resources are less concentrated: Brazil still leads the region, with 30% of researchers regionwide, followed by Argentina, with nearly the same figure, and then Mexico, Colombia and Chile. These five countries have 86% of the total number of agricultural researchers in the region. Given the concentration of agricultural R&D in just a few countries, regional cooperation is a necessary condition for increasing the efficiency of R&D and improving the dissemination of findings.

■ Figure VI.4 ■

Latin America and the Caribbean (selected countries): average spending on agricultural research and development, 2000-2012

(Percentages of agricultural GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Agricultural Science and Technology Indicators (ASTI).

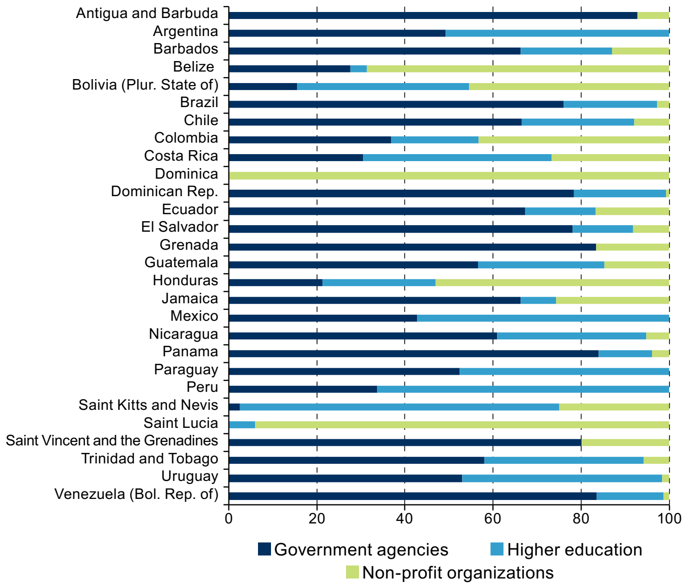
D. Public investment in research and development plays a key role in the dissemination of agricultural technology to developing countries, supplementing private investment

- Worldwide, the agriculture sector accounts for approximately 3% of GDP, and spending on research and development (R&D) in this sector amounts to nearly 5% of total spending on R&D. Around one third of investment in agricultural R&D (including the food industry) is made by the private sector, and two thirds by the public sector. In the developed countries, this spending is split nearly evenly between the public and private sectors. In contrast, in low- and middle-income countries, the public sector outspends the private sector in agricultural R&D by a factor of fourteen (Pardey and others, 2015).
- In Latin America and the Caribbean, 55% of agricultural researchers are employed by government agencies, 40% by universities and the remaining 5% by non-profit organizations, with significant differences from country to the next. For example, in Antigua and Barbuda, the Bolivarian Republic of Venezuela, Brazil, the Dominican Republic, El Salvador, Grenada, Panama and Saint Vincent and the Grenadines, government agencies employ over 70% of agricultural researchers, whereas in Mexico and Peru, two thirds of agricultural researchers work for institutes of higher education.
- Underlying these distributions are major differences in the countries' institutional structures. In Brazil, for example, government-funded agricultural research is carried out at both the federal and state level. The Brazilian Agricultural Research Enterprise (EMBRAPA) is the lead agency at the federal level, but most states also have agricultural research entities, which focus on local issues. Institutes of higher education play an important role too. In Mexico, the National Institute of Forestry, Agriculture and Livestock Research (INIFAP) is the principal government institution involved in agricultural research but as in Brazil, several other government agencies conduct research at both the state and national level.
- In Argentina, the National Institute for Agricultural Technology (INTA) is the entity responsible for R&D and extension services in the sector. Other government agencies that work on agricultural R&D are grouped under the National Council of Scientific and Technical Research (CONICET).
- In Colombia, the Colombian Corporation of Agricultural Research (CORPOICA) is the largest of five agricultural R&D agencies run by the government, but the country has a large number of producer organizations that conduct research on a wide variety of crops.

Figure VI.5

Latin America and the Caribbean (selected countries): average spending on agricultural research and development, 2000-2012

(Percentages of agricultural GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Agricultural Science and Technology Indicators (ASTI).

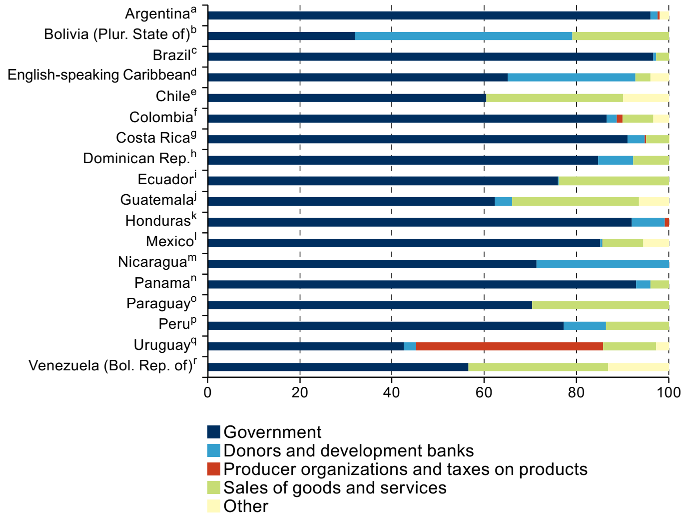
E. Regional organizations are key players in the development of science, technology and innovation in the agriculture sector

- In addition to the institutions run by national and local governments, the region has a large number of supranational organizations that conduct or promote agricultural research. Examples include the Inter-American Institute for Cooperation on Agriculture (IICA), the subregional programmes for the development of cooperative technology (Cooperative Programme for the Technological Development of Agriculture in the Southern Cone (PROCISUR), Cooperative Programme for Technology Research and Transfer in the South American Tropics (PROCITROPICOS), Cooperative Agricultural Research and Technology Transfer Programme for the Andean Subregion (PROCIANDINO) and Cooperative Programme for Agricultural Research Programme for the Caribbean (PROCICARIBE)), the Central American Agricultural Technology Integration System (SICTA), the Centre for Tropical Agricultural Research and Education (CATIE) and the Caribbean Agricultural Research and Development Institute (CARDI). Internationally, the global headquarters of three CGIAR consortium centres are located in the region: the International Center for Tropical Agriculture (CIAT), in Colombia; the International Maize and Wheat Improvement Center (CIMMYT), in Mexico; and the International Potato Center (CIP), in Peru (Stads and others, 2016).
- In Chile, the lead government agency for agricultural R&D is the Institute of Agricultural Research of Chile (INIA). In academia, Universidad de Chile and Universidad de Concepción conduct the bulk of research. And with the establishment of non-governmental research centres in the past decade, non-profit organizations are playing an increasingly important role in agricultural research.

Figure VI.6

Latin America and the Caribbean (selected countries): average spending on agricultural research and development, 2000-2012

(Percentages of agricultural GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from the Agricultural Science and Technology Indicators (ASTI).

[a] National Institute for Agricultural Technology (INTA).
[b] National Institute for Agricultural and Forestry Innovation (INAF).
[c] Brazilian Agricultural Research Enterprise (EMBRAPA).
[d] Caribbean Agricultural Research and Development Institute (CARDI).
[e] Institute of Agricultural Research of Chile (INIA).
[f] Colombian Corporation of Agricultural Research (CORPOICA).
[g] National Institute for Innovation and Transfer of Agricultural Technology (INTA).
[h] Dominican Agriculture and Forestry Research Institute (IDIAF)
[i] National Agricultural Research Institute (INIAP).
[j] Institute for Agricultural Science and Technology (ICTA).
[k] Agricultural Science and Technology Division (DICTA).
[l] National Institute of Forestry, Agriculture and Livestock Research (INIFAP).
[m] Nicaraguan Institute for Agricultural Technology (INTA).
[n] Panamanian Institute for Agricultural Research (IDIAP).
[o] Paraguayan Institute for Agricultural Technology (IPTA).
[p] National Institute for Agricultural Innovation (INIA).
[q] National Agricultural Research Institute (INIA).
[r] National Institute for Agricultural Research (INIA).

- Other countries in the region have very different agricultural R&D systems. For example, the Bolivarian Republic of Venezuela, the Dominican Republic, Ecuador, Nicaragua, Panama and Paraguay each have a single agricultural research institute that employs the vast majority of the national research corps, and just a few specialized agencies. By contrast, in Costa Rica and Uruguay, the institutes employ a small percentage of agricultural researchers, and the higher education sector plays a more dynamic role. With the exception of Jamaica and Trinidad and Tobago, in the English-speaking Caribbean, the agriculture ministries employ a small share of the countries' agricultural researchers, and most research work is carried out by CARDI (Stads and others, 2016).
- The sources of financing for the main government agricultural R&D agencies vary significantly. In Argentina, Brazil, Honduras and Panama, over 90% of these agencies' activities are funded from the government budget. Meanwhile, in the Plurinational State of Bolivia, and to a lesser extent in Nicaragua and the English-speaking Caribbean, international donors and development banks are a major source of funding. The sale of goods and services by research agencies generates recurring revenue in the Bolivarian Republic of Venezuela, Chile, Ecuador, Guatemala, Paraguay and Peru. Uruguay is the only country in the region in which a large share of sector R&D is funded by producer organizations.

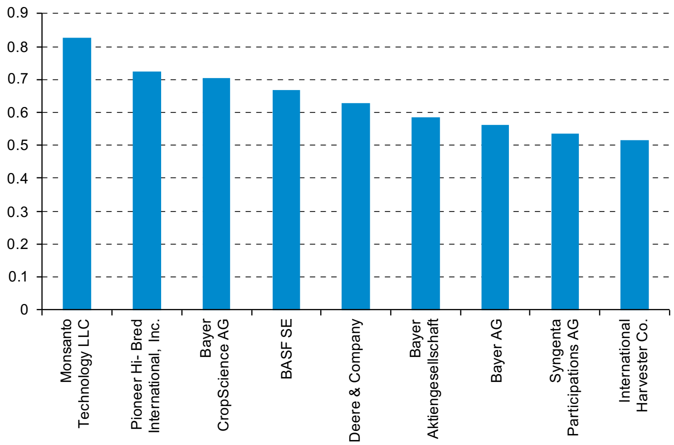
F. There are opportunities for the region to take advantage of its ties with global seed and agrochemical companies and conduct more agricultural research and development

- Worldwide, the proportion of private investment in research and development (R&D) that goes to the agriculture sector has increased in recent decades. In the United States, for example, which spends more than any other country in the world on agricultural R&D, the private sector accounts for roughly half of all agricultural R&D spending (and a full three quarters of total R&D spending). The pattern repeats throughout the developed world. Between 1950 and 1990, private investment in agricultural R&D grew faster than public investment in this category in the United States, though both public and private spending have grown at virtually the same rate for the past 25 years (Pardey and others, 2015).
- A study on R&D strategies at 11 transnational seed and agrochemical companies, including the six largest in the sector, finds that their spending on R&D in the area of agrochemicals alone came to US$ 2.6 billion in 2014, equivalent to 5.4% of the agrochemical sales of these companies (McDougall, 2016). Research by the world's largest agrochemical companies is conducted not only in the countries where they are headquartered but in others as well. In total, 41% of this category of spending by these companies goes to R&D in Europe, 28% in North America and 15% in Latin America (McDougall, 2016).
- The concentration of agricultural R&D in the hands of a few companies in the agrochemical and seed sector has major implications for the direction of technological progress in agriculture. First, these companies generate fewer public goods by comparison with the wave of innovations that occurred during the Green Revolution from 1950 to 1970, when the public sector was at the fore of R&D. Second, private investment in agricultural R&D also tends to be more concentrated in terms of areas of knowledge and crops, limiting its positive externalities and the potential for technology transfer to other countries and different types of farmers.
- Among the nine companies obtaining the most patents in class A01 of the International Patent Classification (IPC) ("Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing") in the patent offices of the United States and the European Union, in the framework of the Patent Cooperation Treaty (PCT), are the six largest companies in the agrochemical and seed sector. These nine companies received 6% of the patents issued in agriculture between 2006 and 2016. In the subclass A01H ("New Plants or Processes for Obtaining Them; Plant Reproduction by Tissue Culture Techniques"), these same companies obtained 30% of the patents issued during that period.
- These companies conduct very little research with local staff in Latin American and Caribbean countries. Moreover, the number of patents obtained by the six largest agrochemical and seed companies in partnership with an applicant from the region is a very small, less than 1% of the total number of patents granted to these companies. This stands in contrast to the importance of the region for these companies in terms of sales of agrochemicals and seeds and even spending on R&D.

Figure VI.7

Latin America (selected countries): patents obtained in class A01[a] of the International Patent Classification (IPC), by company, 2006-2016

(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of World Intellectual Property Organization (WIPO), Patentscope.

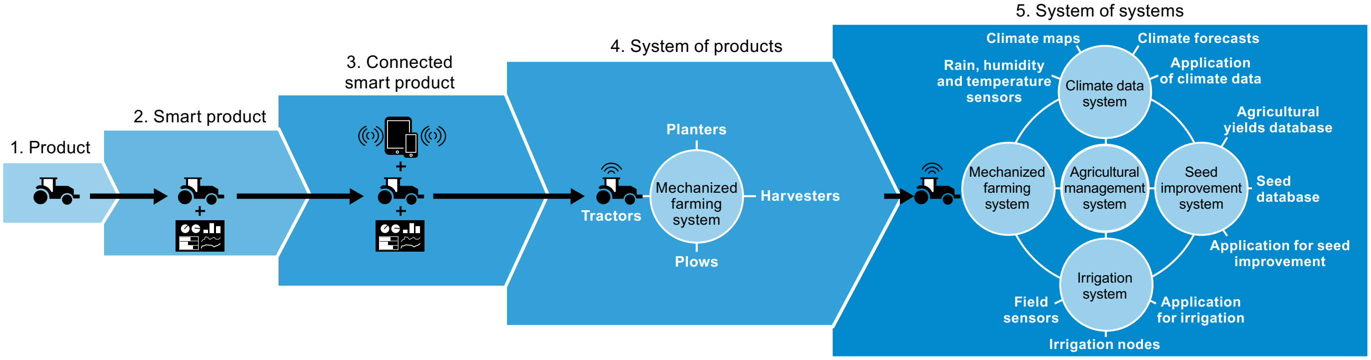
[a] "Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing."

G. It is crucial to tap the potential of generic technologies to drive innovation in agriculture

- The agriculture sector must contend with the challenges posed by food security for a growing global population, sustainability of natural resources, environmental limits and climate change. This creates an important window of opportunity for the region. To meet these challenges and take advantage of the opportunity they represent, the region must deploy a strategic agricultural research agenda to address them. Part of such an agenda would consist of bringing existing technology —both agricultural and more general, science-based technology— to countries that do not yet have access to it through international scientific collaboration.
- With this in mind, it is essential to look at how the vertiginous progress of techno-economic paradigms is linked to innovation and scientific developments in agriculture.
- The Internet of Things means enabling objects, machines and individuals to interact remotely through the Internet at any time and place, thanks to the convergence of technologies. In the 1990s, the fixed Internet connected 1 million users via personal computers. In the 2000s, the mobile Internet connected over 2 million users via smart phones. By 2020, it is expected that the Internet of things will have connected 28 million objects ranging from items of personal use, like smart watches, to automobiles, household devices and industrial machinery. The implementation of the Internet of Things has disruptive impacts in all sectors and is sparking dramatic changes in social and economic processes, particularly job creation.
- The biggest disruption will occur with the digitalization of services, and the sectors most affected will be manufacturing, transport and storage, information, commerce, health and finances. This is clearly evident in the investments that various industries are making or planning to make in this technology. The forestry and agriculture sector, however, is behind on this front considering the investment growth projected in other economic sectors for 2019.
- With the development of the Internet of Things, opportunities are also emerging for entrepreneurship and innovation in agriculture. The Internet of Things is increasingly linked with smart farming, which includes, at one end of the spectrum, fast, low-cost, user-friendly applications for small and medium-sized agriculture, and at the other end, expensive, sophisticated systems that make intensive use of information and communication technologies in all phases (data collection, processing and analysis) and the application of variables through the Global Positioning System (GPS) and geographical information systems (GIS). This is the case with precision agriculture, which targets mainly large producers.

■ **Diagram VI.1** ■

Innovations in ICT: Internet of Things and agricultural development



Source: Economic Commission for Latin America and the Caribbean (ECLAC), 2015.

VII. Eco-innovation: taking advantage of the opportunities presented by the new global models of sustainable consumption and production

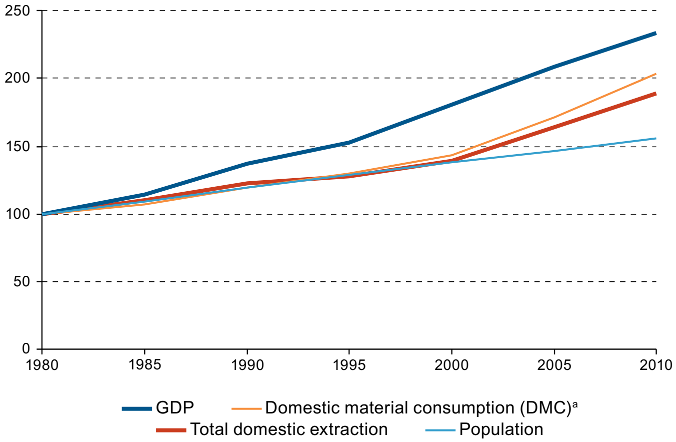
A. Material productivity must be increased in Latin America and the Caribbean

- The idea of non-material economic growth (ECLAC, 2006) has given rise to the concept of decoupling, which involves reducing resource use (commodities, energy, water and land) by unit of economic activity, thereby increasing efficiency and minimizing adverse environmental impacts. To generate a decoupling impact, the productivity of material consumption must be higher than the economic growth rate (UNEP, 2011).
- Worldwide, there are ongoing environmental pressures due to sustained growth in the consumption of renewable and non-renewable resources. Nearly 72 billion metric tons per year of materials were extracted, harvested and consumed around the world in 2010, double the volume in 1980. The use of material resources is expected to continue growing, based on economic activity, to 100 billion metric tons by 2030. In this context, strategies must be developed to dematerialize economies, in order to reduce resource use and lessen the environmental impact.
- Although the use of material resources continues to rise in absolute terms at the global level, progress has been made in decoupling the extraction of these resources, their consumption and economic growth, especially in developed countries. However, this is not the trend that is being seen in the economies of Latin America and the Caribbean, where, instead, there is a clear correlation between economic activity and material consumption. With this in mind, the challenge that lies before the region's countries is to take advantage of the opportunities offered by the new models of consumption, which are more respectful of the environment, promote technological change processes and mitigate the growing pressures on natural resources.

Figure VII.1

Global trends in material consumption and extraction, GDP and population, 1980-2010

(Index: 1980=100)



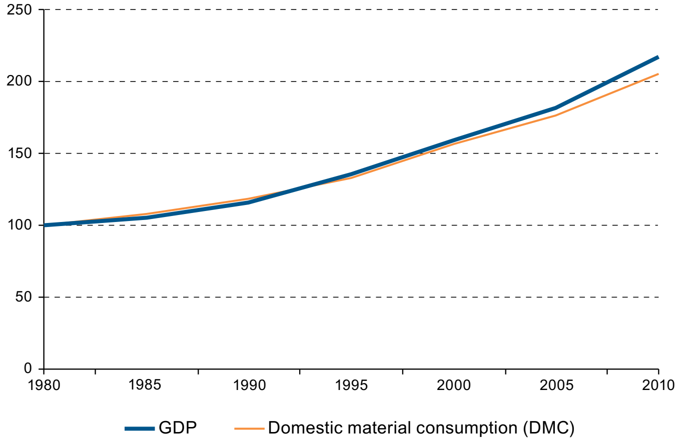
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of "Material flow data" [online database] http://www.materialflows.net/home.

[a] Domestic material consumption (DMC) is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports. It includes: biomass and biomass products; metal ores and concentrates, raw and processed; non-metallic minerals, raw and processed; petroleum resources, raw and processed; other products; and waste imported for final treatment and disposal.

Figure VII.2

Latin America and the Caribbean: trends in material consumption and GDP, 1980-2010

(Index: 1980=100)

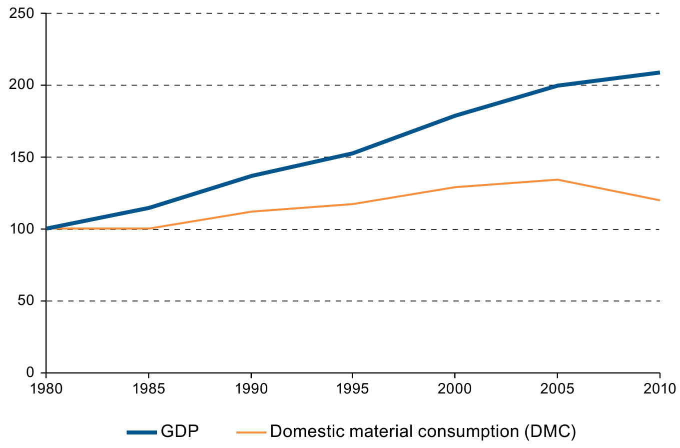


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of "Material flow data" [online database] http://www.materialflows.net/home/.

Figure VII.3

Organization of Economic Cooperation and Development (OECD): trends in material consumption and GDP, 1980-2010

(Index: 1980=100)



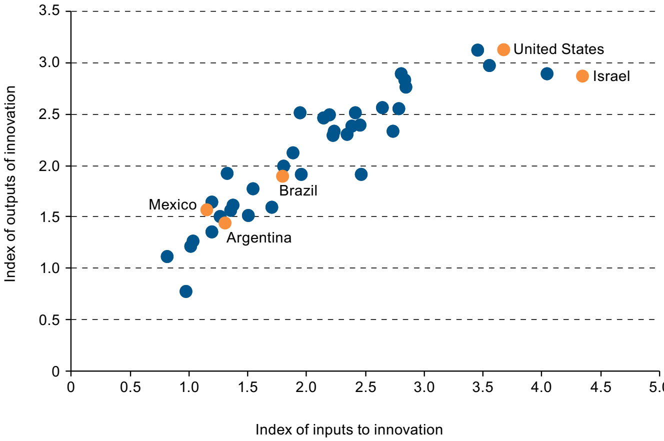
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of "Material flow data" [online database] http://www.materialflows.net/home/.

B. The environment for promoting eco-innovation is weak

- The generation and dissemination of clean technologies and more sustainable production models has the potential to unleash technological change processes and new cycles of innovation. For this, human capital and scientific and technological development are key inputs.
- The Global Cleantech Innovation Index (GCII) reflects the ability of countries to generate entrepreneurial activity based on clean technologies that can be successfully commercialized. To compile the index, conditions in 40 countries are evaluated based on 15 indicators related to the creation of new clean-technology businesses and the commercialization and development of innovations. In 2014, Brazil, Argentina and Mexico were ranked 25th, 32nd and 36th on the index. A comparison of the sub-indices of these countries against the global average can be used to identify some trends and failures and in the region's innovation environment.
- In the case of Argentina, early-stage entrepreneurial activity is robust, but the country is below average in terms of general inputs to innovation. It stands out only on commercialized cleantech innovation, with very strong cleantech corporate revenues, but it lacks more established publicly traded companies. Brazil is below average in terms of general inputs to innovation and emerging cleantech drivers but is among the top three countries in commercialized cleantech innovation, primarily due to its biofuels industry. However, it is weak on emerging cleantech innovation, with few patents and low venture capital investment. Mexico is below average on every indicator except general inputs to innovation, which are supported by a strong entrepreneurial culture and new tax incentives. The government's new policies for promoting the sector and an increase in the budget for research and development are expected to improve access to financing and investment. Limited venture capital investment and the absence of high-profile companies account for the country's low score on cleantech innovation.

■ **Figure VII.4** ■

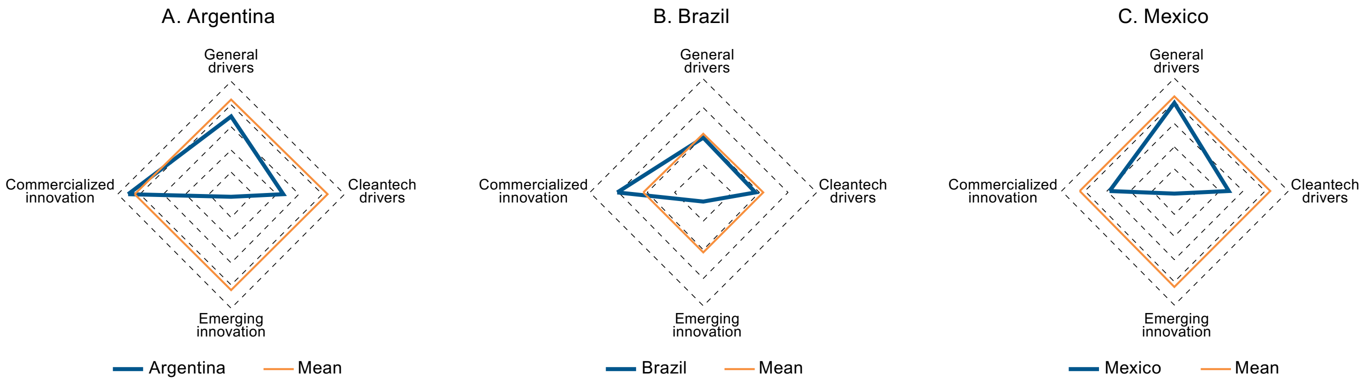
Global Cleantech Innovation Index, 2014



Source: Economic Commission for Latin America and the Caribbean (ECLAC), *The Global Cleantech Innovation Index Report 2014*, 2014.

■ **Figure VII.5** ■

Argentina, Brazil and Mexico: Global Cleantech Innovation Index, 2014



Source: Economic Commission for Latin America and the Caribbean (ECLAC), *The Global Cleantech Innovation Index Report 2014*, 2014.

■ **Table VII.1** ■

Composition of the Global Cleantech Innovation Index, 2014

Inputs to innovation		Outputs of innovation	
General innovation drivers	Cleantech-focused innovation drivers	Evidence of emerging cleantech innovation	Evidence of commercialised cleantech innovation
(i) General innovation inputs	(i) Cleantech-friendly government policies	(i) Early-stage private investment	(i) Revenue of cleantech companies
(ii) Entrepreneurial culture	(ii) Government R&D expenditure	(ii) High-impact cleantech start-ups	(ii) Renewable energy consumption
	(iii) Access to private finance for cleantech start-ups	(iii) Patents in cleantech sectors	(iii) Late-stage private investment and exits
	(iv) Country-attractiveness of renewable energy infrastructure		(iv) Successful publicly traded cleantech companies
	(v) Cleantech cluster programmes and initiatives		(v) Employees

Source: Economic Commission for Latin America and the Caribbean (ECLAC), *The Global Cleantech Innovation Index Report 2014*, 2014.

C. Although there has been a significant increase in environmental patents, they remain scarce in the region

- The production of environmental patents can serve as a measure of a country's research and development in this area and its capacity to develop technologies associated with environmental stewardship. The production of environmental patents in Latin America between 2000 and the period 2010-2012 (average) increased sharply and by a greater magnitude than overall increase in patents. However, the number of environmental patents in the region represents just 0.6% of the worldwide total. Analysis of data by country shows that between 2000 and 2012 Mexico patented the most clean technologies, closely followed by Brazil. Argentina is in third place, followed by Chile, Colombia, Peru, the Bolivarian Republic of Venezuela and Costa Rica.
- The main types of clean technologies patented by Latin American countries since 2000 have been for environmental management, followed by technologies for reducing greenhouse gas emissions in the generation, transmission and distribution of energy and, to a lesser extent, technologies for reducing those emissions in the transport sector, technologies for climate change adaptation in the water sector, technologies for reducing greenhouse gas emissions in the construction sector and, lastly, technologies for capturing, storing and eliminating greenhouse gases.

Table VII.2

Number of total patents and environmental patents issued,[a] 2000-2012

Region	2000			2005			Average for 2010-2012		
	Total patents	Environmental patents	Environmental patents *(percentage of total patents)*	Total patents	Environmental patents	Environmental patents *(percentage of total patents)*	Total patents	Environmental patents	Environmental patents *(percentage of total patents)*
World	439 887	23 490	5	625 549	37 533	6	600 615	55 797	9
Organization for Economic Cooperation and Development (OECD)	396 790	21 466	5	485 894	30 320	6	505 971	49 585	10
Latin America (19 countries[b])	1 232	60	5	1 920	146	8	3 311	329	10

Source: V. Gutman and A. López (2016), "Capacidades para la innovación ambiental en América Latina", paper prepared for the project "Towards a set of indicators for greener production", Santiago, 2016, unpublished, on the basis of OECD Stat [online database] http://stats.oecd.org/.

[a] Environmental patents include a wide spectrum of technologies related to environmental and water conservation and climate change mitigation.

[b] Argentina, Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Plurinational State of Bolivia and Uruguay.

Table VII.3

Latin America: Types of clean technologies patented, 2000-2012

(Percentage of total environmental patents)

Type of clean technology	2000	2005	Average for 2010-2012
Technologies for environmental management	61.93	57.00	48.39
Technologies for the reduction of greenhouse gas emissions in the generation, transmission and distribution of energy	12.83	27.32	29.6
Technologies for the reduction of greenhouse gas emissions in the transport sector	11.55	7.90	7.84
Technologies for climate change adaptation in the water sector	6.84	1.38	7.68
Technologies for the reduction of greenhouse gas emissions in the construction sector	5.55	6.40	5.46
Technologies for the capture, storage and elimination of greenhouse gases	1.28	0.00	1.03

Source: V. Gutman and A. López (2016), "Capacidades para la innovación ambiental en América Latina", paper prepared for the project "Towards a set of indicators for greener production", Santiago, 2016, unpublished, on the basis of OECD Stat [online database] http://stats.oecd.org/.

D. There has been rapid growth in the number of companies obtaining environmental certifications in the region

- Environmental certifications can serve as an indicator of the degree to which companies are adopting environmental management practices and thus the degree to which environmental policies are a priority in the production sector. According to data provided by the International Organization for Standardization (ISO), the number of certifications in environmental management systems (ISO 14001) has grew sharply in South America and Central America between the periods 2000-2004 and 2010-2014 at a rate of 430%, which is very near the global average (439%) but lower than the rate seen in other regions, such as Central and South Asia (680%), the Middle East (655%) and East Asia and the Pacific (588%). The region's share in the total number of certifications remains stable (3%) and growing faster than in East Asia and the Pacific. With respect to national figures in the region, Colombia has the most ISO 14001 certifications, with 30.2% of the total, followed by Brazil, Mexico and Argentina.

Table VII.4

ISO 14001 certifications, 2000-2014

Region	2000-2004 average		2005-2009 average		2010-2014 average		Increase from 2000-2004 to 2010-2014 *(percentages)*
	Number	Percentages of global total	Number	Percentages of global total	Number	Percentages of global total	
Africa	480	1	1 271	1	2 117	1	341
South America and Central America[a]	1 796	3	4 692	3	9 519	3	430
North America[b]	3 745	7	6 659	4	7 219	3	93
East Asia and Pacific	21 144	40	76 317	47	145 520	51	588
South and Central Asia	714	1	3 049	2	5 569	2	680
Europe	24 588	47	67 242	42	111 829	39	355
Middle East	393	1	1 870	1	3 008	1	665
Total	52 860	100	161 100	100	284 781	100	439

Source: V. Gutman and A. López (2016), "Capacidades para la innovación ambiental en América Latina", paper prepared for the project "Towards a set of indicators for greener production", Santiago, 2016, unpublished, on the basis of information provided by the International Organization for Standardization (ISO).
[a] Includes Mexico.
[b] Includes Canada and the United States.

■ **Table VII.5** ■

Latin America: number of ISO 14001 certifications, 2014

Country or territory	Number of certifications	Percentages
Colombia	3 453	30.2
Brazil	3 222	28.1
Mexico	1 452	12.7
Argentina	1 341	11.7
Chile	967	8.4
Peru	353	3.1
Ecuador	189	1.7
Uruguay	147	1.3
Costa Rica	91	0.8
Bolivia (Plurinational State of)	52	0.5
Honduras	35	0.3
Dominican Republic	32	0.3
Puerto Rico	25	0.2
Guatemala	22	0.2
Panama	21	0.2
El Salvador	16	0.1
Cuba	14	0.1
Paraguay	11	0.1
Nicaragua	8	0.1
Total	11 451	100

Source: V. Gutman and A. López (2016), "Capacidades para la innovación ambiental en América Latina", paper prepared for the project "Towards a set of indicators for greener production", Santiago, 2016, unpublished, on the basis of information provided by the International Organization for Standardization (ISO).

E. Regulatory frameworks and environmental policy must be linked to science, technology and innovation policy to drive eco-innovation

- The main discussion in the innovation economy focuses on understanding the factors driving technological innovation and whether these are primarily technology push factors or market pull factors. Some empirical evidence has demonstrated that both are important, but the regulatory framework and especially environmental policy also have a strong impact on eco-innovation.
- Eco-innovations, unlike other technologies such as microelectronics and telecommunications, are not typically adopted on their own, because the technology push and market pull factors do not tend to be strong enough. Studies on the region underline the importance of regulations in promoting environmental practices, especially among small and medium-sized enterprises (SMEs). The literature also recognizes that regulations that prohibit or impose standards on certain activities tend to have consequences on end-of-pipe technology development that, while reducing environmental impact, do not necessarily promote greater efficiency in the use of resources. In contrast, economic incentives can translate more effectively into innovations in production, organizational or commercialization processes.
- In general, the production technologies that are currently in place constitute just one of various different technological paths, but once a path has been chosen, it is not easy to switch to another path involving different technological characteristics.
- Switching to a less polluting technology can be very expensive and may require government intervention (Rovira and Hiriart, 2015). There are two complementary policies that could be useful for advancing the incorporation of less polluting technologies at companies:
  - Strategic niche management, which involves the creation, development, dissemination and controlled elimination of protected spaces for the development and use of promising technologies through experimentation; and
  - Transition management, an approach that supports sustainable transitions for companies in need of system-wide innovations in production and consumption.

Table VII.6

Latin America: recent literature on environmental innovation

Country	Study	Place and sample size	Main findings
Argentina	Research Centre for Transformation (CENIT) (2015), “Pymes y reconversión ambiental: el análisis econométrico”	Buenos Aires, 200 companies, 2013-2015	The main reasons for pursuing environmental management activities are: (i) to comply with local environmental regulations; (ii) to improve the company profile; and (iii) to lower costs; and (iv) to meet market requirements.
Peru	GEA Group/Centre for Eco-efficiency and Social Responsibility (CER) (2015), “Enverdeciendo a pequeñas y medianas empresas: su impacto en la competitividad y el empleo en Lima Metropolitana”	Lima, sample of 307 companies in 22 manufacturing subsectors	Seventy percent of companies implement innovations only in response to external requirements, mainly regulations and social pressure.
Brazil	Maçaneiro, M., S. da Cunha and Z. Balbinot (2013), “Drivers of the Adoption of Eco-Innovations in the Pulp, Paper, and Paper Products Industry in Brazil	All regions of Brazil, pulp, paper and paper products industry, survey of 117 companies	Environmental regulations are the main factor determining the adoption of environmental innovation strategies.
Venezuela (Bolivarian Republic of)	Fernández-Viñé, M., T. Gómez-Navarro and S. Capuz-Rizo (2010), “Eco-efficiency in the SMEs of Venezuela. Current status and future perspectives”	Central region, 54 SMEs	In general, SMEs are reactive, and compliance with environmental regulations is the main reason cited for pursuing environmental management activities.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of V. Gutman and A. López (2016), “Capacidades para la innovación ambiental en América Latina”, paper prepared for the project “Towards a set of indicators for greener production”, Santiago, 2016, unpublished.

VIII. Final thoughts

- The 2030 Agenda for Sustainable Development involves jointly achieving different objectives —in particular, furthering economic growth and social and environmental development. To achieve this, it is essential to attain full employment, promote inclusive industrialization and foster innovation, while also taking account of climate change and environmental impacts.
- The effects of climate change will be felt more directly and strongly by the poorest, who lack access to basic services and health care, are more dependent on natural resources for their livelihoods, and have limited access to the technology and the financial resources needed to adapt. The households worst affected are also those that have the most difficulty recovering from losses, meaning that natural disasters have long-term effects on health, education, nutrition and productivity, and help to engrain poverty and inequality (ECLAC, 2016).
- The new technologies are crucial for responding to the challenges of an ageing population which is increasingly concentrated in large cities. In particular, the Internet of Things may improve the provision of health services and help to build environmentally sustainable, smart and integrated cities. This is part of a new Schumpeterian frontier for innovation and structural change, which has strong synergies with the objectives of equality and environmental stewardship.
- Closing the productivity gap between the countries of the region and the developed world requires bringing more technology-intensive activities and sectors into the industrial structure of the countries that are furthest behind, together with greater knowledge spillovers and production chains that enable them to grow their economies and improve their populations' living standards.
- Digital technologies are a fundamental for moving in that direction. Convergence between Internet-based devices, applications, networks and platforms has become a key factor in economic growth and competitiveness, to the point that the world economy is now a digital economy. Over the last few years, these technologies have experienced exponential growth, attaining unprecedented dissemination in Latin America and the Caribbean: 51% of the region's inhabitants were using the Internet in 2014.
- At the present time, the Internet of Things is one of the key ways of bringing about far-reaching change in the economies; it is being applied in various economic, social and environmental areas, and it has driven progress in sectors such as health (monitoring applications, medication dispensers and telemedicine), the manufacturing industry (robotization, advanced manufacturing, and second-generation machine-to-machine (M2M services), energy, transport, natural resources and smart electricity grids, all clearly linked to the sustainable development goals (ECLAC, 2015). In this context, fast-changing consumption and production patterns pose challenges for Latin American region, for which the production of the new technologies is essentially exogenous.
- Competitiveness and growth in individual countries' will depend largely on their integration into the global digital ecosystem. This will force them to improve their infrastructure, build up human capital and enhance the business environment. Consideration must also be given to the definition of global standards, the regulation of data flows, intellectual property rights and security and privacy of users. These issues should be addressed from a regional perspective. The creation of a digital common market for Latin America and the Caribbean would make it possible to nurture and consolidate the expansion of the digital economy and the development of related activities (ECLAC, 2015).
- Science, technology, innovation and the development of the digital economy are increasingly important in facilitating the move towards new development models. The economic boom in Latin American and Caribbean countries over the last decade, did not generate productivity gains; and, although significant progress was made in the social sphere, the only way to lock-in these achievements and continue advancing towards fairer and more inclusive societies is by redoubling efforts in science, technology and innovation, to facilitate the transfer and construction of technological capabilities and institutional capacities.
- This will require new policies to help local firms, particularly the smaller ones, to access technology. One such policy would be to establish a fund to purchase and release patents that are important from the sustainability viewpoint. Reducing the costs of acquiring technology could have an even greater

impact if it is done within an integrated regional market. This is an initiative that should be taken up by the regional institutions, and could draw upon the positive experiences of public or private funds that purchase patents and license them to their members, a practice that reduces transaction costs and litigation risks (ECLAC, 2016).

- Progressive structural change implies the economy moving forward on a low-carbon growth path and gradually decoupling production from emissions. This will demand the development of technological capabilities and innovations focused on sustainability. The environmental big push is a concentrated investment effort aimed at redefining production and consumption patterns, based on learning and innovation.
- Environmental innovations, although sometimes hard for firms (especially smaller ones) to implement, can become competitive assets, insofar as the regulations in this area ultimately make them more competitive. ECLAC thus believes that the environmental issue offers a great opportunity for a technological and production transformation that will lay foundations for creating high-quality employment. The creation of national centres to analyse, monitor and evaluate implementation of the contributions committed to by each country, would help to achieve these objectives.
- New opportunities for diversifying production are emerging from the application of information technologies to production and the increased density of the industrial fabric, as current technologies and the energy mix are redefined. Examples include the management of smart cities, the expansion of mass transit, the processing of biodiversity, the development of biomaterials and the bioeconomy, eco-labelling, and power generation from renewable sources, with the consequent development of their value chains.
- Capitalizing on the great potential of these technologies will require strengthening human resource capabilities; encouraging the production sector to play a larger role in innovation and technological development; articulating research, development and innovation (RDI) policies in strategic areas; and fostering technology-based SMEs. This means building capacities, reducing entry barriers to concentrated markets and to financing, and developing regulatory frameworks in areas such as biosafety and biorisks, and protection of biodiversity, among other measures.
- The coordination effort implicit in the environmental big push demand new policies and a new institutional system. First, countries must design policies that can be implemented with the institutional capacities at hand or those that can be developed in the short run. Second, policies must be viewed from an operational perspective, taking a production linkaging approach to facilitate interaction with the business sector, incorporation of the territorial dimension, and articulation among different sectors, and the dissemination of knowledge and creation of linkages. Thirdly, the business dynamic requires implementing policies to protect competition, combined with institutions aimed at strengthening good corporate governance practices, protecting the interests of domestic and external investors, so as to enhance the generation and transfer of technology and knowledge.
- Moreover, in a world where economies of scale and scope are increasingly crucial for closing technological gaps, it is essential to promote bilateral or multilateral cooperation to generate, develop and consolidate scientific and technological capabilities, along with production innovation and institutional articulation processes. Regional projects are thus essential for identifying potential areas of interest for cooperation in science, technology and innovation, which in turn could generate major synergies with other cooperation processes are under way in the region, or else be taken up by those projects to strengthen scientific and technological development (ECLAC, 2014).

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Technological trajectories are inseparable from developments in employment and production and it is essential to determine which types of innovation will best serve the region in attaining the threefold objective of economic growth, social inclusion and environmental sustainability enshrined in the Sustainable Development Goals and the 2030 Agenda for Sustainable Development.

Each country's positioning in the global economy depends on its ability to absorb knowledge and move closer to the technology frontier. Where do Latin America and the Caribbean stand in this respect? Unfortunately, despite the progress made, indicators of innovation efforts and access to technology —which are among the themes addressed in this document— are not promising. Our countries are also poorly positioned to absorb and participate in knowledge creation in new technology paradigms, particularly in the general-purpose technologies that spread through and influence the entire production system.

These are some of the challenges that our region faces, and for which we aim to help craft solutions by identifying public policies that can pave the way to more inclusive and sustainable development.

In offering this document to the governments and people of Latin America and the Caribbean, ECLAC endeavours to provide an overview of the main themes related to science, technology and innovation, against the backdrop of the progress of the industrial Internet and advanced agriculture and manufacturing.

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