THE IMPERATIVE OF INNOVATION

CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

Prepared for the EU-LAC Summit of Heads of State and Government
Madrid, 2010

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This document was prepared by a team of the Science and Technology Division of the IDB, under the responsibility and direct supervision of Flora Painter, Division Chief. Pluvia Zúñiga had the main responsibility for writing the document, which draws from recent research work at the Division, most notably the chapter on innovation and productivity written for the flagship IDB document Development in the Americas (2010), as well as from the upcoming Compendium of Indicators of Science, Technology and Innovation for Latin America and the Caribbean. Rafael Anta, Gustavo Crespi, Matteo Grazzi, Juan José Llisterri and Juan Carlos Navarro reviewed the document and contributed different sections. Mikael Larsson and Alison Cathles lent invaluable research assistance. Serrana Mujica managed the editing and graphic design.
Graphic Design by Círculo Salvo (circulosalvo.com). Comments and contributions by Carlos M. Jarque and Luis Alberto Fierro (ORP/EUR) are acknowledged.

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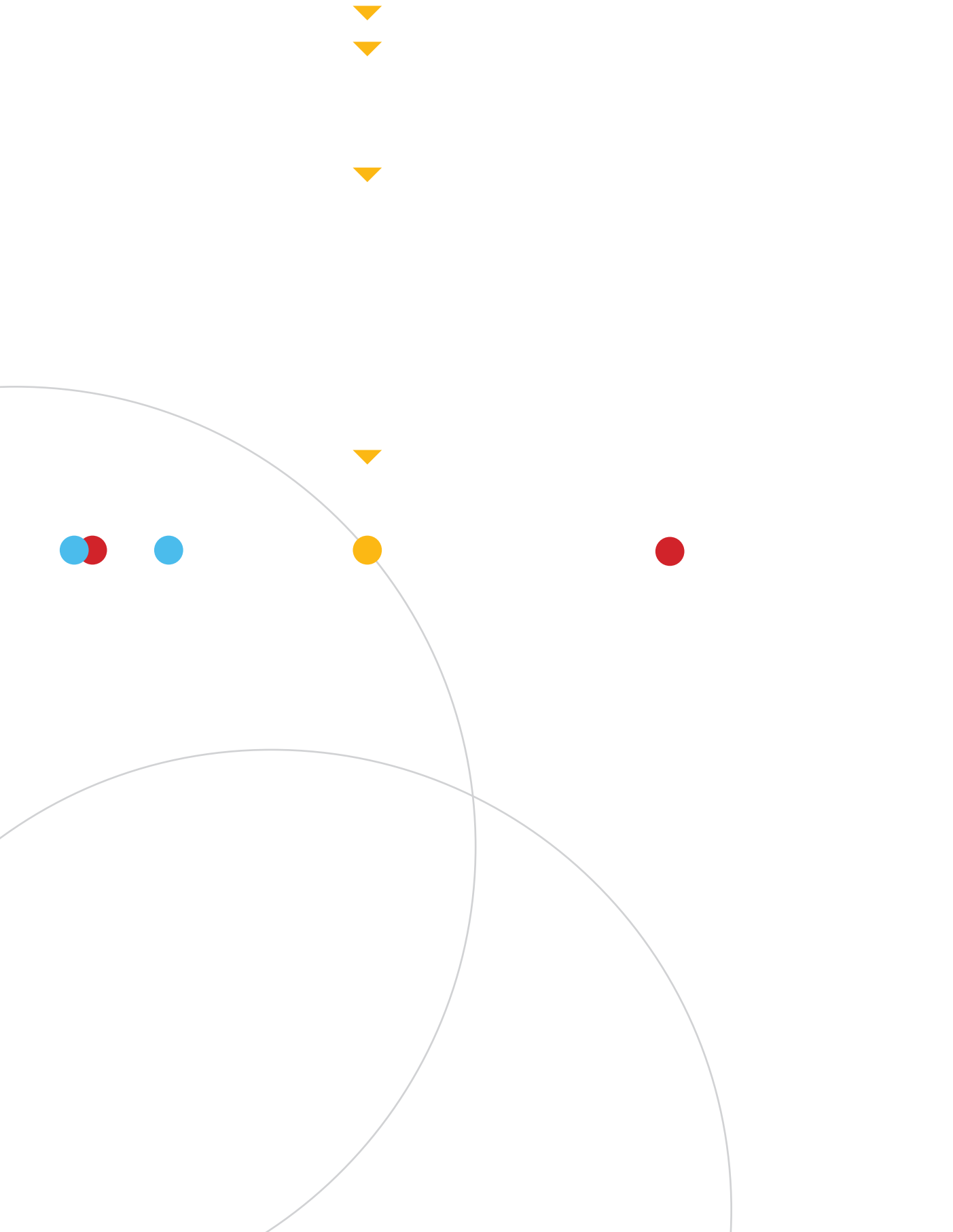

We live in a knowledge society. Innovation and technology are transforming the way we live, learn, work, travel, and relate to each other, on a daily basis. The countries of Latin America and the Caribbean (LAC) are inextricably linked to these worldwide trends and must develop the necessary capacity to tap into global information and knowledge flows in order to acquire, process, adapt, apply, disseminate, and create knowledge.

As this volume indicates, LAC countries in general have not been investing enough, or particularly well, in science, technology and innovation. Adoption of critical technologies, such as computers and the Internet, lags behind the levels in advanced economies and emerging competitors. Investment in scientific and technological development pales when compared to that of almost any other region of the world, particularly recent successful cases of accelerated economic growth in East Asia. Investment in human capital in science and engineering has been insufficient to reach a critical mass. With a few exceptions, firms, especially the majority of small enterprises, have not incorporated innovation into their strategies and operations.

Several countries in our region have moved forward in ways that signal a concern for these issues, and, over the years, have managed to build a visible capacity in science and technology. Both the Inter-American Development Bank (IDB) and the European Union (EU) have been key partners in these positive developments.

Yet, progress in this area remains uneven and clearly insufficient. The pace of technological change has accelerated over the past decade, and so has international competition for products and services that are increasingly knowledge-intensive. Without exception, every country that can be singled out as a successful development story in recent history has invested significantly and over a sustained period of time in science, technology and innovation to produce world-class technological prowess. Indeed, leadership in innovation has driven economic growth and prosperity, and not the other way around. Solutions to developmental challenges such as poverty and social inclusion, productivity, natural disasters, sustainable energy and climate change, and access to quality health and education, can hardly be tackled today without significant technology and innovation efforts.

Latin America and the Caribbean cannot remain remote to these compelling lessons. Firms, governments and universities need to do far more to increase and improve investment in science, technology and innovation.

The IDB welcomes and fully supports the Sixth Summit of Heads of State and Government of the European Union and Latin America and the Caribbean (EU-LAC) in Madrid, Spain (May 2010), with its focus on innovation as a core theme. We present this document with the hope of contributing to shed light on the situation of science, technology and innovation in our region, in order to provide inputs for the Summit, and for the actions to be implemented in the near future. In so doing, the document puts forth a call for expanded EU-LAC cooperation and the consolidation of a strong partnership. Today, the most important socio-economic challenges –take climate change as an example- are not unique to any one country or region; rather, they must be addressed at a global scale. As the largest source of external financing and technical assistance in science, technology and innovation in Latin America and the Caribbean, the IDB stands ready to contribute to and facilitate this partnership.

Luis Alberto Moreno
IDB President

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I. Introduction

The arrival of the knowledge economy has highlighted the increasing importance of innovation and intellectual assets as sources of competiveness and long-term growth. At the same time, climate change and the obvious limits to conventional sources of energy represent challenges that require immediate action and coordination on an international scale. In response to these challenges, governments in the developed world increasingly recognize that reinforcing investment in knowledge and innovation capabilities will lead the process of economic recovery and to the development of new sustainable economic competencies (OECD, 2009).

In addition to facing these global challenges, countries in Latin America and the Caribbean (LAC) are still struggling to address national concerns such as alleviating poverty, reducing inequalities, and abating the persistent productivity gap with respect to developed economies. The region confronts the challenge of leveraging the opportunities presented by globalization and technological change without compromising sustainable development and social justice.

In striving to address global and national concerns, countries in LAC are starting to recognize the importance of innovation, not only for economic growth and development, but also for the well-being of society. It is increasingly acknowledged, at least in political discourse, that by reinforcing technology competencies, countries will be able to reorient their economies towards a virtuous circle of productivity growth, higher value-added activities, and increased living standards. Furthermore, new technologies offer new solutions for the advancement of the social agenda. In particular, information and communication technologies (ICT) provide valuable instruments to enhance social inclusion through applications in areas such as education, health care, and more transparency in the provision of public services. Finally, emerging technological revolutions such as biotechnology and nanotechnology might provide LAC economies with new tools to face global challenges such as climate change, energy efficiency, and food security.

This document reviews the conditions for innovation in Latin America and the Caribbean and tackles the question of how innovation and technology can contribute to creating increased prosperity in these countries. The document is a contribution from the Inter-American Development Bank (IDB) to the process of policy dialogue and identification of priorities to boost cooperation in science, technology and innovation between the European Union (EU) and Latin America and the Caribbean (LAC). Europe has historically played a major role in the development of science, technology and higher learning in Latin America and the Caribbean. The aim of this document is to serve as the basis for a discussion of expanded opportunities for collaboration between the two regions.

The discussion that follows reviews where the region stands in terms of science, technology and innovation (STI) and Information and Communication Technologies (ICT) compared to more developed countries. The diagnostics are accompanied at every turn by a discussion of the challenges that countries face in developing new approaches for the design, execution and governance of innovation and technology policies. Overall, this discussion emphasizes the need to place innovation at the very heart of countries' economic development agenda and as a key area of cooperation between policy makers, agencies, business and society, with an explicit reference to how technology can lend a contribution to tackle the challenges defined by the Millennium Development Goals. Finally, the document describes the IDB's programs in STI and the special initiatives the Bank has launched to promote technology for social inclusion. It concludes with a description of areas where greater cooperation and policy dialogue between LAC and the EU is possible and the role the IDB can play.

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II. Challenges in Science, Technology and Innovation in Latin America and the Caribbean

Innovation, Economic Growth and Development

Innovation is, in its essence, the transformation of new ideas into economic and social solutions. Innovation can be the execution of a new way to do things more efficiently (a more effective use of resources), a new or significantly improved product (good or service) or process, a new marketing practice, or a new organizational method in business practices, workplace organization or external relations (OECD and Eurostat, 2005). For firms and countries, innovation is at the heart of sustainable competitive advantage, increased productivity, and economic progress.

Policy makers and researchers alike recognize that beyond the simple accumulation of physical and human capital, innovation is a key determinant of long term growth. Indeed, empirical evidence shows that about half of the differences in income levels and growth rates among countries are due to differences in total factor productivity (Hall and Jones, 1999), while previous research also reports that research and development (R&D) explain up to 75% of the differences in total factor productivity growth rates, once externalities are taken into consideration (Griliches, 1979). Additionally, available evidence from OECD countries points to the fact that it is investment in R&D that causes productivity growth and not the other way around (Rouvinen, 2002). In other words, innovation investments are a critical input in long term growth, rather than a simple result of that growth.

Consistent with previous findings, the social returns of innovation investments tend to be higher than the opportunity costs (the returns to physical capital). For developed economies, social rates of return to R&D have been estimated at 40 percent or more (Hall, Mairesse and Mohnen, 2009). In addition to generating new knowledge, investments in innovation also have a direct effect on the creation of absorptive capacities. Innovation activities (and in particular R&D investment) are fundamental for the development of new competencies and skills needed to search out, acquire and adapt existing technology. In other words, innovation activities are a key driver of catching-up (Rostow, 1960, Cohen and Levinthal, 1989).[1] It is not surprising that in developing countries, social rates of return to innovation are even higher. Lederman and Maloney (2003) found that the social returns to R&D

[1] Consistent evidence has been documented about the importance of knowledge and technological capabilities for catching-up (Griffith, Redding, and Van Reenen, 2002). This has been the case not only for Japan in the early 1930s (Johnson, 1982) but also for the so-called newly industrialized economies in Asia, notably South Korea (Kim, 1998; Nelson and Pack, 1999; Kim and Nelson, 2000). In both cases, catching up has been associated with former and conscious technological capacity building by countries (Kim, 1997).

for countries in Latin America are quite substantial. For medium income countries, such as Mexico and Chile, they found an average return of around 60 percent and for relatively poorer countries, such as Nicaragua, an average return closer to 100 percent.

Given the robust evidence supporting the importance of innovation for long term economic growth, during the past 20 years there has been increasing interest among policy makers in defining the main drivers of innovation. For example, endogenous growth models emphasize that R&D expenditures should be seen as an investment decision affected by the institutional and market conditions of each particular economy (Romer, 1990 and Aghion and Howitt, 1992). Thus these models suggest that by affecting these factors, governments can encourage R&D investment decisions and economic growth.

The growing literature on Innovation Systems also provides deeper insights into the determinants of the innovation process (Freeman, 1987; Lundvall, 1992). This literature recognizes that innovation is not a simple linear process that flows smoothly from research to application, but rather that it is a collective process that involves interactive learning among several actors (researchers, firms, users, etc.) and requires multiple inputs (research, training, production facilities, marketing, etc). Therefore, on this basis, an Innovation System is defined as the set of economic agents, institutions and practices that perform and participate in relevant ways in the process of innovation. Actors in a "national innovation system" (firms, universities, public agencies and governments, financial systems and markets) contribute jointly and individually to the generation of knowledge, its diffusion, its use and exploitation, its adaptation and its incorporation into production systems and society (Freeman, 1987; Metcalfe, 1995). As such, the National Innovation System approach provides the framework within which governments form and implement policies to influence the innovation process.

Yet changing the NIS and its functioning in ways that will encourage the building of a knowledge infrastructure is a long term process (Hall, 2005) that demands continued efforts and policy coherence over time. As stated above, there are considerable potential benefits stemming from innovation for LAC countries. This leads to an obvious question regarding the extent to which countries in the region are taking advantage of this potential and taking the necessary steps.

Comparative Performance of Science, Technology and Innovation in Latin America

Two sets of measures are normally used to benchmark the performance of innovation systems. The first set includes those measures that capture innovation-related investment efforts, which basically consists of measuring the inputs needed for innovation, such as expenditures in R&D and the number of researchers. The second set of measures consists of output indicators, which measure how successful innovation investment has been. This includes variables such as scientific publications, patents and technology exports.

The following sections present a benchmarking analysis of LAC performance along the lines of these two sets of indicators.

The Inputs: Investment in Knowledge and Human Capital

In almost every one of the relevant dimensions of the STI landscape, Latin American and Caribbean countries differ greatly from the advanced economies. Overall, LAC countries display substantial

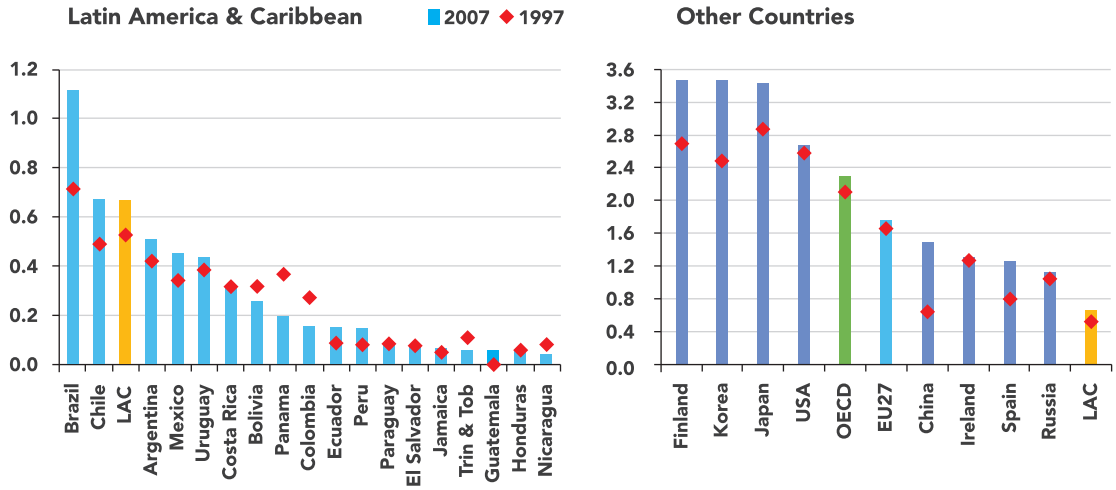
underperformance with respect to OECD and European Union countries, and to emerging economies such as China, India and some Central European countries.

While from 1997 to 2007, R&D expenditures as a share of GDP (R&D intensity) grew consistently in the advanced economies, improvements in LAC countries have been modest on average (figure 1). According to RYCYT (Red de Indicadores de Ciencia y Tecnología) estimates, R&D investment in the region in 2007 represented 0.67% of GDP compared to 0.52% in 1997. During the same period, OECD countries increased R&D intensity from 2.1 to 2.3 %. In addition, contrary to developed economies where most of the countries continue to increase this investment, efforts on improving R&D investment in LAC are concentrated in a handful of countries. In fact, Brazil is responsible for 60% of R&D expenditures in the region in 2007. R&D intensity in Brazil has reached 1.11% of GDP and is the highest in LAC.

In terms of income levels, most Latin American countries still under-perform in terms of R&D intensity. In other words, they invest significantly less than they would be expected to invest according to their income level. Within LAC economies, the R&D gap with respect to their potential has been smaller in countries such as Chile, Uruguay, Costa Rica and Brazil (40-50%, see IDB, 2010). At the opposite end, European innovation champions such as Denmark, Sweden, and notably Finland appear frequently as dramatic over-performers with R&D intensities above what their income level predicts (e.g. Lederman and Maloney, 2003 and IDB, 2010).

Another characteristic of the LAC region is low participation by the private sector in innovation efforts (figure 2). Financing of R&D (and performance) continues to be highly concentrated in public institutions (governmental agencies and universities), averaging 60% of the total effort, compared to 36% for the OECD.

Figure 1 | **R&D expenditure as a percentage of GDP 1997 (or nearest available) and 2007 (or latest available)**



Notes | There are two scales, one for each group of countries. The earliest data available for El Salvador and Guatemala are 1998, for Honduras, 2000, and for Jamaica and Paraguay, 2001. Brazil had no available data for 1997, so data from 1996 are used. The latest data available for Bolivia, Jamaica and Nicaragua are 2002, for Chile, Honduras and Peru are 2004, and for Mexico and Paraguay are 2005. Data for Korea excludes R&D in the Social Sciences and Humanities and data for the United States excludes capital expenditure. Data for OECD Total, EU27 and Ireland 1997 are based on projections or national estimates. As this document progresses, care has been exercised to indicate a variety of sources. The reader should be warned that the definition of geographical or categorical aggregates, such as "LAC" may sometime contain small differences in the precise number of countries included. We have avoided details in what follows, in order to unburden the document of lengthy technical details, yet the reader is referred to IDB (2010) for the full details in the case of every source, label and country grouping.

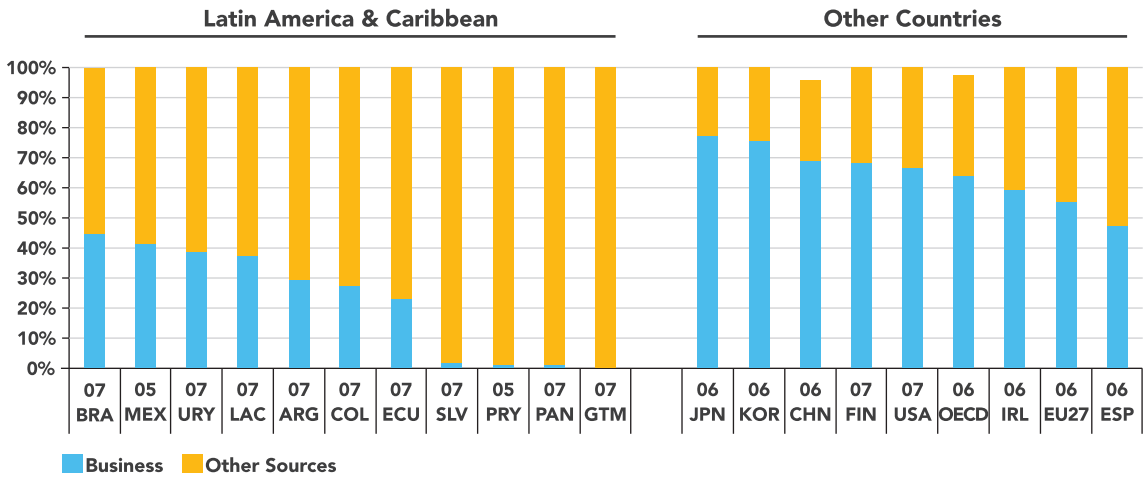
Sources | OECD Main Science and Technology Indicators 2009-1 and RICYT.

The differences regarding human capital are similarly large. According to the data available, in 2007 there was only one researcher per 1,000 in the labor force on average in LAC. This number is seven times lower than the OECD average and nine times lower than in the United States. There are also substantially fewer PhDs (in science and technology) per capita. There were also substantially fewer doctoral graduates per capita in the LAC region in 2007 compared to the USA and Spain.[2] On average, there are 2.5 PhDs per 100,000 inhabitants in LAC and only 1.6 of those are in science and engineering, whereas in the USA and Spain[2] there are 18.8 and 14.8 PhDs per 100,000 inhabitants, respectively, and of those, half of them are in Science and Engineering (IDB, 2010).

Fewer researchers are employed in business (40 percent on average) in LAC, in contrast with OECD countries (64 percent of researchers are in business) (figure 3).

This low participation is explained by a combination of factors such as: deficient mechanisms for market insertion, the orientation of research competencies (in many cases towards basic research), mismatch between the supply and demand side (lack of relevance or applicability to industry needs) and particularities of institutional settings that preserve the isolation of research and education systems from the private sector (lack of incentives for mobility). Another problem is that industries fail to recognize the importance of research for learning and innovation. Companies in LAC have systematically favored innovation strategies that focus on the purchasing of technology rather than promoting the endogenous generation of new ideas, neglecting in this process the importance of research capabilities for absorption of technology. As a consequence, universities in the region produce researchers and research skills that are not used by the production system.

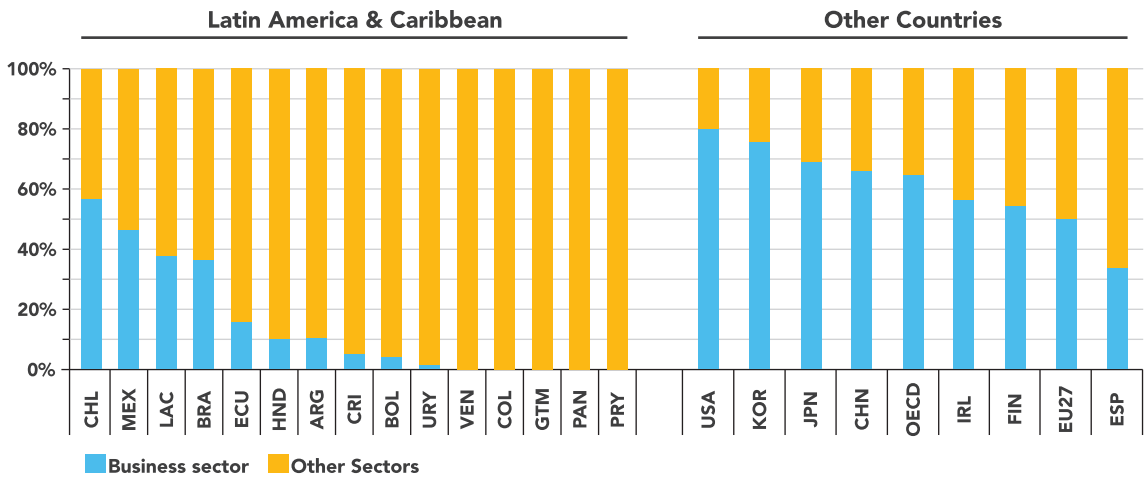
Figure 2 | **R&D expenditure by funding source, 2007 (or latest available)**



Notes | Government, Higher Education, Private Non-Profit, Foreign and Other have been grouped to form "Other Sources". LAC data are estimated by RICYT.
Sources | OECD Main Science and Technology Indicators 2009-1 and RICYT.

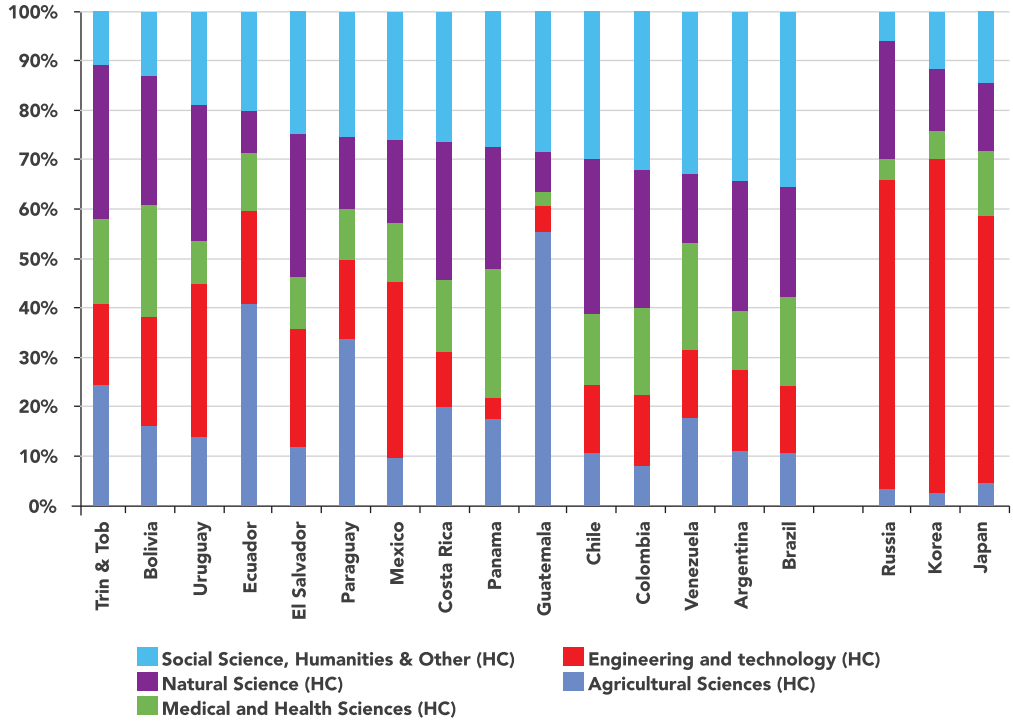
[2] Figures depicting the PhD graduates and Science and Engineering PhDs are not provided in this paper, but can be made available upon request, and will be published in a forthcoming compendium of indicators (IDB, 2010). Data from the USA are from 2006.

Figure 3 | **Researchers by sector of employment, 2007 (or nearest available)**



Notes | Government, Higher Education and Private Non-Profit have been grouped under "Other Sectors". The latest available data for Uruguay and Bolivia are 2002, Honduras are 2003, Chile are 2004, Costa Rica are 2005, Mexico, Ireland, OECD Total and the United States are 2006. Threshold for data depicted is 2002.
Sources | OECD and RICYT.

Figure 4 | **Distribution of researchers by field of science 2007 (or latest available)**



Notes | Social Sciences and Humanities, Other and Unspecified were combined into one category. Latest Available data from Chile are 2000, Bolivia and Panama are 2001, Mexico are 2003, Costa Rica are 2005, and Argentina, Brazil, Colombia, Guatemala, Trinidad & Tobago and Uruguay are 2006. Data from the Russian Federation are underestimated or based on underestimates. HC stands for head count.
Source | UNESCO Institute for Statistics.

The nature of research in LAC economies is also different from that in OECD countries (figure 4). As explained earlier, there is less applied research (notably research skills in engineering and technology). The share of researchers working on engineering and technology (in total researchers) ranks between 10 and 30%, whereas countries such as Japan or Korea display rates of 60%. In fact, in numerous LAC countries, there are more researchers in social sciences and humanities than in agricultural sciences or engineering and technology.

Figures 1 to 4 highlight not only the large differences between LAC and the OECD, but also the striking heterogeneity of the Latin American region itself. A closer look at the data indicates that Brazil—and to some extent Argentina, Chile, and Mexico—have started to evolve towards developing a technological profile closer to that of advanced economies, while the rest of the region still lags well behind.

Recent studies (e.g., Maloney and Rodríguez-Clare, 2007) have suggested that international benchmarking exercises such as those presented above may distort the realities of innovation in Latin America. They argue that the comparison fails to adjust for the very different economic structures of developing and advanced economies. Thus, the argument goes, the optimal level of innovation in a given LAC economy may be lower than the OECD average simply because of the low technological intensity of the natural resources and other sectors characteristic of the region. Thus, instead of an "innovation shortfall," the poor results for LAC may be a natural consequence of a particular economic structure.

However, the empirical evidence suggests that even after correcting for the industrial structure, the conclusion of low technological intensity holds, confirming the existence of an innovation shortfall in LAC (Maloney and Rodriguez-Clare (2007)). For example, Benavente and Bravo (2009), comparing Chile and Australia in the mining sector, and Chile and Finland in the paper pulp sector, find that R&D investments are considerably lower in Chile and that this explains much of the observed difference in productivity. Over the long term, a commitment to technological change and more technology-intensive industries may very well steer economic structure towards knowledge and innovation intensive activities, raising productivity and economic growth along the way.[3]

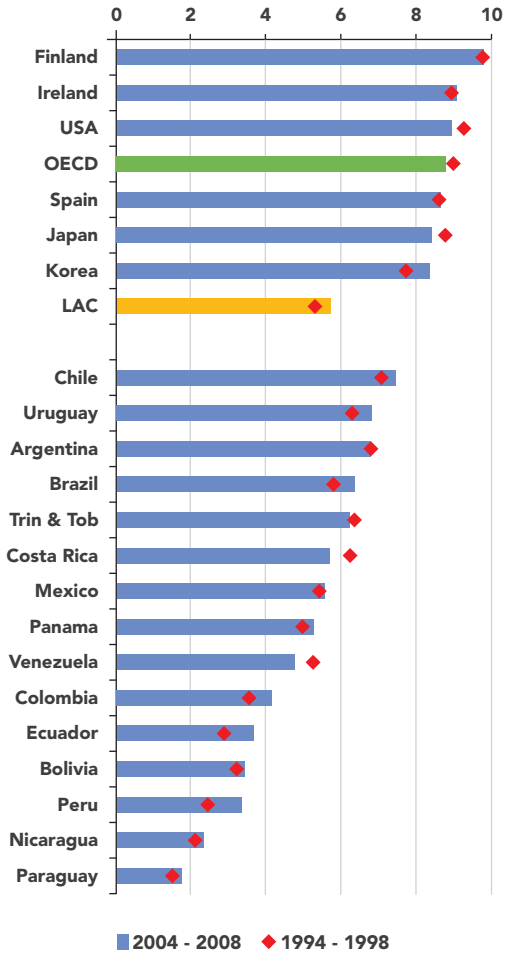
The Outputs of Knowledge: Scientific Production, Patents and Technology Exports

Scientific performance continues to lag well behind developed countries: there are fewer than 50 scientific publications per million inhabitants in LAC as opposed to over 300 in advanced economies (NSF, 2008). In a normalized scale (with respect to 170 countries in the world), between the mid 1990s and the mid 2000s, the region has slightly improved its position (figure 5). Here again, the picture is more varied if one looks at the figures for Brazil, Argentina and Mexico, countries that have reached the top 50 in the world in terms of scientific publications, and by looking at the rate of growth of publications from Latin America, which has tripled over the past decade and a half, outpacing other regions and consequently reducing the gap in this regard.

Despite some achievement regarding scientific performance, the technological performance of the LAC economies has

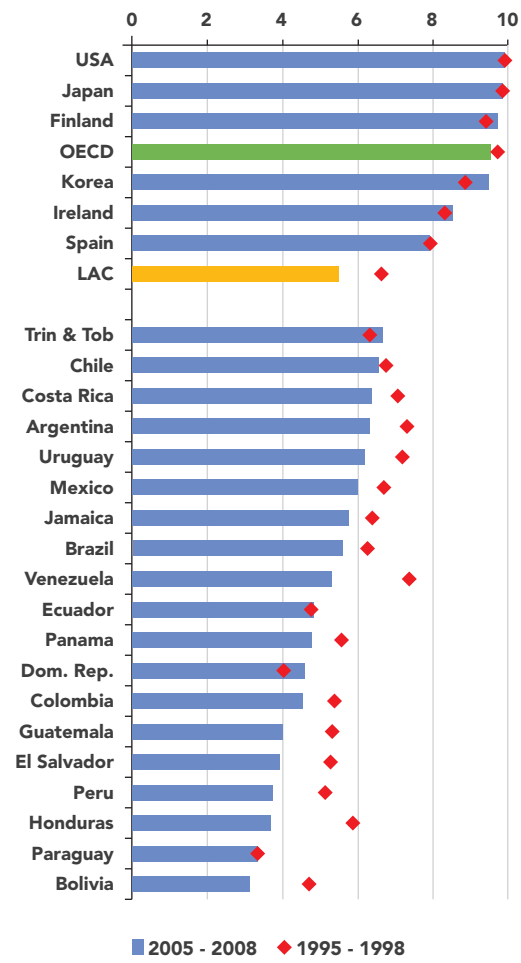
[3] Cimoli et al (2006) have analyzed structural change in the economic structure of Latin America between 1970 and 2000 and compared it to South Korea, Finland and the US. They find that growth in South Korea and Finland is associated to a change in the economic structure in favor of knowledge intensive sectors, which have a role in disseminating technology throughout the whole economy. In contrast, in the Latin American countries evidence shows a reduction in the participation of high technology sectors in favor of natural resource intensive sectors

Figure 5 | **Scientific publications per 100,000 inhabitants, 1994-1998 and 2004-2008 (Normalized Country Rank 0-10)**



Sources | Calculations using Reuters-Thomson ISI(R) National Science Indicators (2008) and World Bank Development Indicators database.

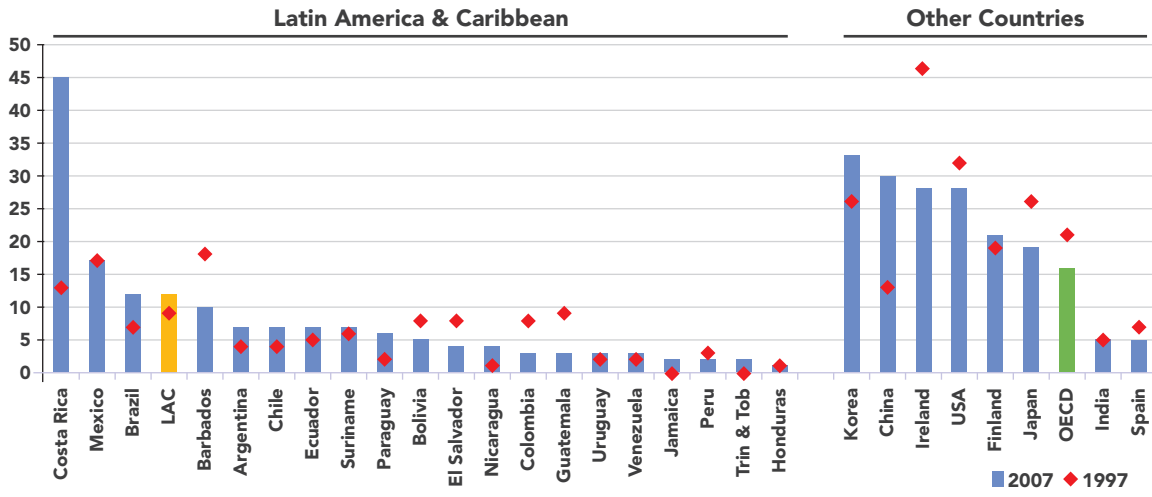
Figure 6 | **Patents per 100,000 inhabitants, 1995-1998 and 2005-2008 (Normalized Country Rank 0-10)**



Sources | USPTO and World Bank Development Indicators database.

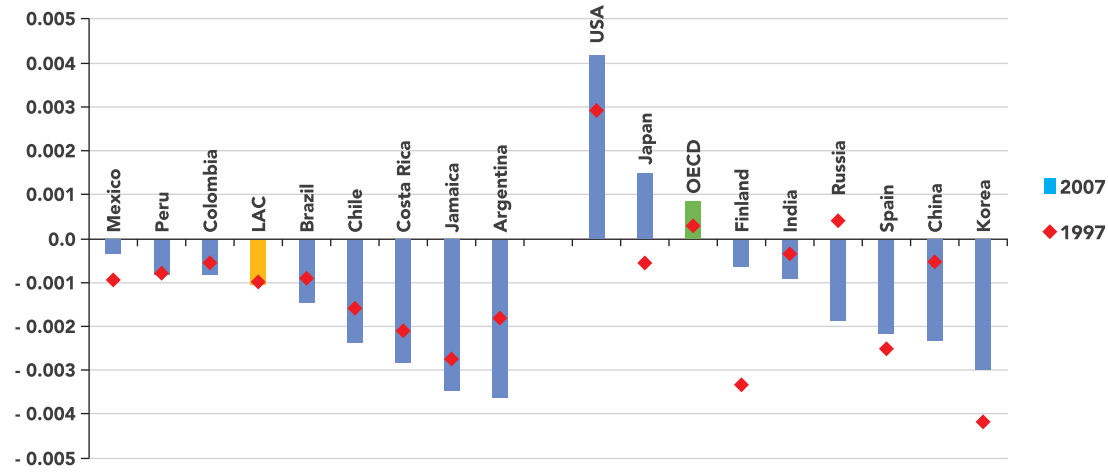
remained extremely poor. Indeed, LAC has declined in its international position in patenting (figure 6): on a scale of 0-10 LAC passed from 6.5 to 5.5 in about a decade (see figure 6). Patents per 100,000 inhabitants reached 150 for South Korea in 2005 (U.S. Patent Office), while they were less than one in LAC. The low technological intensity of Latin American economies is also evident in the relatively minor technological content of exports from all but a few countries in the region (figure 7). According to trade balance statistics, LAC countries have increased their dependence on technology services from abroad (Figure 8). Payments for cross-border licensing, purchase of intellectual property, R&D services and engineering contracting, and other technology services surpass receipts to a large extent. This tendency concerns most of the countries, including the largest ones like Argentina, Brazil or Chile. Countries such as Finland or Spain exhibit a contraction in the technology balance of payments deficit.

Figure 7 | **High technology exports (% of manufactured exports) 1997 and 2007 (or latest available)**



Notes | Latest available data for Chile, Costa Rica, Guyana and Venezuela are from 2006.
Source | World Development Indicators.

Figure 8 | **Technology balance of payments (percent of GDP) 1997 and 2007 (or latest available)**



Notes | Latest available data for Costa Rica are from 2005; for India and Mexico are from 2006.
Source | World Development Indicators.

Scientific Specialization

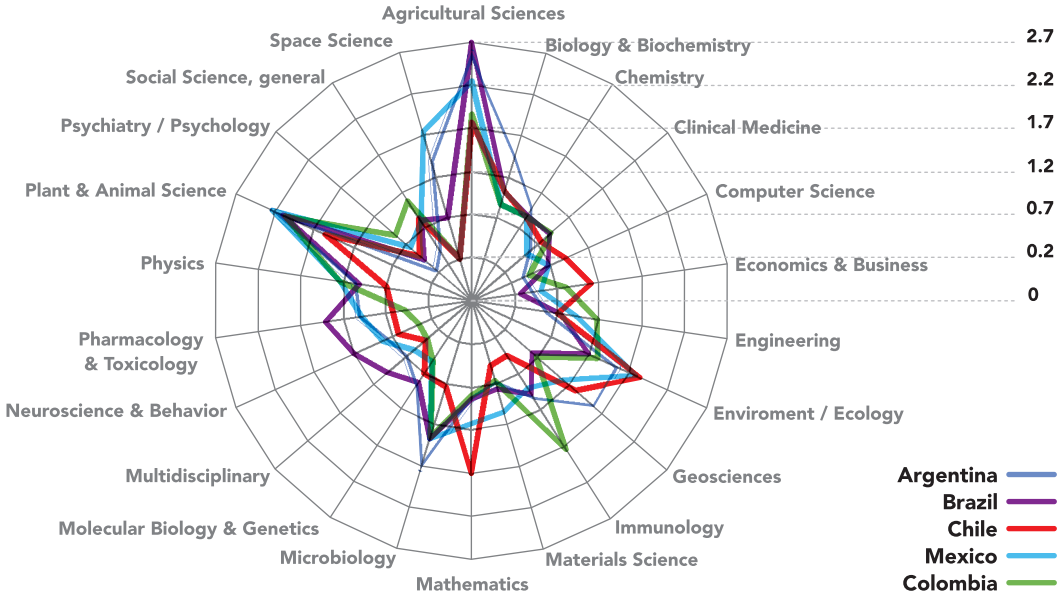
Despite the disappointing general trends, not everything is negative in LAC science. Over the years, the region has managed to build scientific capacities in four major fields: microbiology, environment ecology, agriculture and plant and animal sciences.[4] In figure 8 the areas of stronger specialization of countries are those with the sharp spikes (with levels of specialization superior to 1.5).

The region has fewer relative scientific capacities in more "horizontal" sciences (that is, sciences with a cross-sector impact) such as engineering, materials and computer sciences, and multidisciplinary

[4] A country is specialized if it has a higher intensity of scientific production in a given field than the world average in the same field; an index superior to one indicates specialization.

research. Having scientific competencies in these areas is important as these fields serve as enablers for leveraging scientific productivity in other areas. This is particularly the case for computers and, recently, for materials science (which is especially relevant given the range of opportunities offered by nanotechnology).

Figure 9 | **Relative scientific specialization in LAC countries**



Source | Calculations using Reuters-Thomson ISI(R) National Science Indicators (2008).

Innovation in Firms

For companies, innovation means the transformation of ideas and knowledge into new economic advantages such as higher productivity growth, opening of new markets, and higher market shares. Hence firms play a major role in national innovation systems: they are the agents in charge of transforming knowledge into new economic solutions for their own benefit and the economy as a whole.

Innovation by firms in LAC reflects in essence the weaknesses that exist at the national level in terms of STI. Most of the firms are far from the technological frontier, and innovation strategies are essentially oriented to the acquisition of embodied (foreign) technology, with concerns mainly focused on how to integrate foreign technology into production systems. As a result, innovation outcomes are not novel and are focused mostly on "adaptation" activities, that is, acquisition of knowledge or technologies that are new to the firm but already exist in local or global markets (Navarro et al, 2010; IDB, 2010).

Hence, firms in LAC display a very different profile in terms of innovation activities compared to firms in industrialized nations:

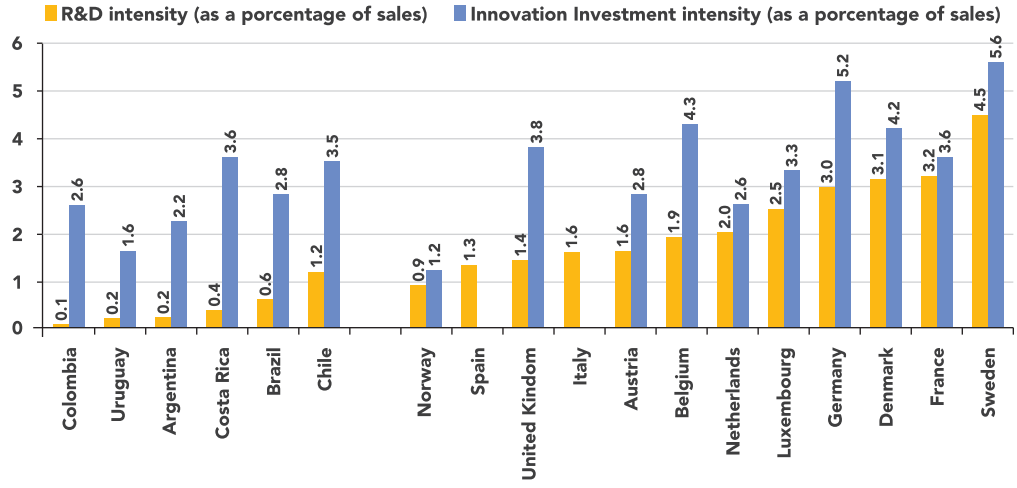
- One characteristic is the low level of expenditure and intensity of effort in R&D (figure 10). On average, firms' R&D intensity (as a percentage of sales) is lower than 0.2 percent, inferior by far to the 1.61 European or the 1.89 OECD averages. As shown in figure 10, the differences between LAC and OECD countries in terms of the intensity of innovation investment by firms is less pronounced given the broad definition of innovation activities.[5]

[5] Following the Oslo Manual, innovation activities include the acquisition of technology embodied in capital goods and equipment, hardware and software, the contracting of R&D services, technology transfer activities such as acquisition of disembodied technology (licensing and buying of intellectual property, know-how and other technical services); training, engineering, and consulting services, among others (OECD and Eurostat, 2005).

• A second feature is the high concentration of innovation effort on the purchase of capital goods and equipment related to innovation activities (figure 11). Expenditure on these items represents between 50 and 80 percent of total expenditure on innovation, while the corresponding share in OECD countries varies in a range between 10 and 30 percent. In OECD countries, R&D expenditure is frequently the main item of innovation investment.

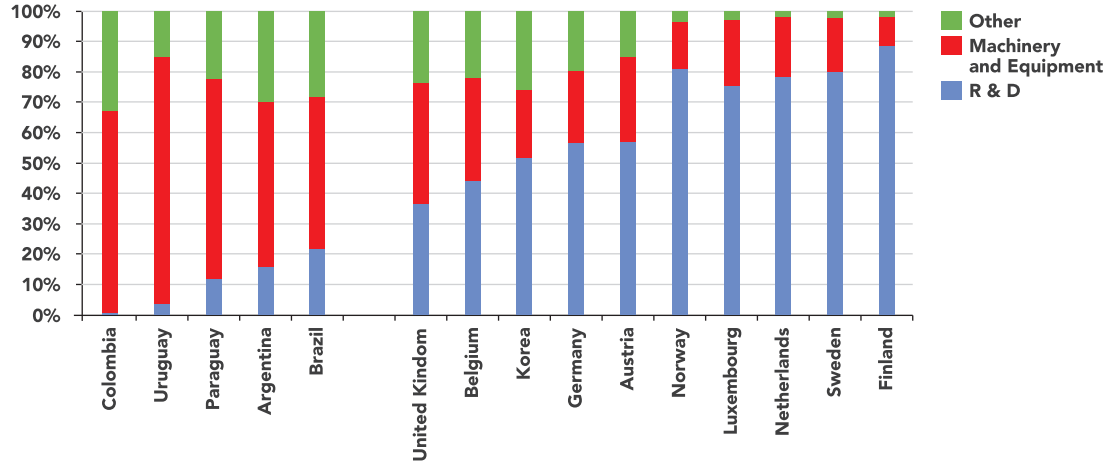
• Most of the private R&D is concentrated in very few firms. For instance, in Argentina, one firm constitutes one-third of R&D expenditure in the whole manufacturing sector, according to the 1998-2001 innovation survey.

Figure 10 | **Investment in innovation by firms**



Notes | Indicators refer to the Manufacturing Industry. Weighted shares are reported only in the case of OECD countries. The indicators reported are averages in the total sample of companies (except for Chile, Spain and Italy whose averages correspond to shares of the total number of innovating companies).
Sources | Innovation Surveys (Colombia: 2005; Uruguay: 2006; Chile: 2005; Argentina: 1998-2001 and Costa Rica: 2008. Data for OECD countries are from OECD (2009) except for Spain and Italy (Eurostat).

Figure 11 | **Distribution of innovation expenditures by firms**



Notes | Indicators refer to the Manufacturing Industry. Indicators are weighted except for Uruguay, Argentina, and Colombia.
Sources | Innovation Surveys (Colombia: 2003-2004; Uruguay: 2005-2006; Chile: 2004- 2005; Argentina: 1998-2001; and Costa Rica: 2008). Data for OECD countries are from OECD (2009) except for Spain and Italy (Eurostat).

The combination of low R&D efforts and high investment in technology embedded in machinery could signal problems (Navarro et al, 2010). Even though acquiring technology by buying equipment and sophisticated machines can be an important step for catching up and advancing toward the technological frontier, the impact of embedded technology at the firm level can be very limited if internal absorptive capabilities (in the form of R&D investment or human capital dedicated to innovation activities) are absent.

Innovation surveys provide further insights into the way firms finance innovation activities and how firms participate in the national innovation systems. These two aspects are highly valuable to inform policy making and design actions. Information from firms confirms that:

- Internal sources constitute the main source of financing for innovation, representing more than 70 percent of total financing, followed by commercial bank financing (between 10 and 20%). Public financing is a minor source of financing for firms in LAC. According to innovation surveys, less than 6% of firms in the manufacturing industry in Latin America and the Caribbean received public financing for innovation activities (Chile reports the highest share with 8 percent of firms receiving public aid). These LAC figures are dwarfed by European averages.

- Links between firms and national scientific institutions and universities are weak. Statistics based on innovation surveys show that Latin American firms most often establish technological cooperation agreements with clients and suppliers. Available evidence suggests, however, that most cooperative activities have the objective of obtaining information and carrying out training activities (i.e. Anllo and Suarez, 2009).[6] Universities and technology institutions have relatively minor importance as partners for innovation activities.

Obstacles to Innovation in Latin American and Caribbean Firms

The previous section showed that countries in LAC are still lagging behind in terms of science, technology and innovation capabilities. The most dramatic deficit in R&D investment is in the business sector. Some of these problems are due to failures of markets to provide finance and sufficient incentives for innovation. This situation clearly highlights the need for effective policy design and new approaches for public policy.

Along with the need for a favorable macroeconomic (and microeconomic) environment, public policy needs to address the fragile articulation of national innovation systems, the particular needs of small and medium size firms, and the creation of new firms, as well as strive for a better balance between basic and applied research (more oriented to resolution of local problems and industry demands). Further progress is also needed in terms of the provision and enforcement of appropriate regulatory frameworks for innovation.

According to innovation surveys, the main obstacles to innovation, as reported by firms in Latin America themselves are: i) constraints in securing financing for innovation (high costs of innovation and risks), ii) the inability by firms to wait for long periods of time (perceived or real) before investments can be recovered or a positive return realized (rates of return), iii) the small size of the market and iv) the shortage of qualified personnel.

[6] In Argentina, according to the innovation survey of 1998-2001, 84% of firms that cooperated with other actors of the national innovation systems for purposes of information and 58% for training purposes; only 21% engaged in cooperation for R&D. In Colombia (according to the Pilot test of the Survey of Technological Development 2 over the period 1999-2002, EDT2), the percentages of firms (within those that reported links with agents that provide technological services) are 31, 50 and 15%, respectively.

The information available from innovation surveys points to lack of financing as a major barrier for innovation investment in LAC firms (Navarro et al, 2010; Anllo and Suarez, 2009). This situation might reflect, in part, problems in the functioning of the financial markets at large. Yet some of the failures in financial markets are intrinsically due to the particular nature of knowledge (its intangible nature and the fact that it can be appropriated by others) and the risky nature of innovation investments (see box 1).

To tackle the problem of "market failure" in finance, several countries in the region have been implementing support programs through subsidies or tax incentives. Governments, by sharing risks, contribute to reducing the uncertainty of innovation and therefore stimulate companies to invest in R&D. However, according to available statistics, these programs have so far failed to reach a critical mass of potentially innovative firms.

The reported lack of skilled personnel reflects deficits in the supply of technological services and capabilities, as well as issues related to the poor coordination of different components of national innovation systems, such as universities and commercial firms. Overall, the statistics reported earlier in the paper regarding the availability of human capital (PhDs, researchers and their specialties) confirm the perception of firms regarding the deficit of qualified technical and professional personnel with relevant skills for innovation activities. This holds true even for the larger economies in the region. Problems linked to market structure and market size suggest a lack of integration of the regional market, which confines many businesses to their domestic -- often small -- markets. Should this be the case, it would

Box 1 | Underinvestment in Innovation: The Market Failures

The problem of appropriability of knowledge is one of the main reasons why the level of investment in R&D is below the social optimum (Arrow, 1962). Appropriation of knowledge means that innovation can be appropriated by others who did not bear the cost of invention.[7] As knowledge shares some characteristics of public good (non rival and non-excludable good, and indivisibility), firms may be unable to exclude others from its use and appropriation, and as a result, inventors (and firms) are not able to recoup R&D costs and will inherently invest less than expected in innovation. Intellectual property rights (IPRs) (patent, trademark, copyright, etc.) aim at alleviating this failure by providing legal (temporary) rights for market exclusion. In the case of patents, through disclosure of inventions, the patent system intends to counterbalance exclusion by ensuring the diffusion of new knowledge.[8]

Given the risky nature of innovation investments, access to credit is difficult for innovating firms. Investment in innovation (notably R&D) is uncertain as it is difficult to know ex-ante the success or outcomes of R&D (and economic impact) that will be achieved.[9] Therefore it is difficult to negotiate a loan over insecure assets and to have contracts based on knowledge assets as collaterals or warranties.

Difficulties in accessing finance arise then because of the asymmetric information between innovators and potential financiers. This means that the parties involved in a transaction do not have the same access to information for decision making leading to problems such as moral hazard and adverse selection. As a result, transactions do not occur or they occur in sub-optimal conditions with high costs of credit.[10] For these reasons, public and private agencies develop joint funding and credit lines for firms, and specialized agencies are created to monitor and evaluate ideas on innovation (thus reducing uncertainty and information asymmetries).

[7] It is frequently assumed that the cost of imitation can be zero. In reality, however, imitation is costly and can even be as much as half the cost of the original innovation (Mansfield et al, 1982).

[8] The IPR system is not costless and, as with other policies, its effectiveness depends more broadly on the institutional development and adequate enforcement of laws. The IPR system is expected to work jointly with competition and antitrust policy and interact with technology transfer policies (e.g. universities and public research institutions). In particular, close interaction and joint work with competition and antitrust policies is needed to monitor abuses of the systems by companies seeking to influence competition.

[9] This problem is particularly accentuated in basic research and that is one of the reasons to provide further support (subsidies or tax incentive policies) to this type of project compared to applied research or development.

[10] More recently, new practices are emerging regarding the valuation of intellectual property, notably patents (their quality and economic value), their monetization (expanding uses of IPR assets and revenue, e.g. patent trade) and their use as financial instruments (collaterals, insurance, and as means of securitization, Yanagisawa and Guellec, 2009).

imply diseconomies of scale for innovation projects, many of which require relatively large investments upfront and longer time horizons to realize a profit.

Still other regulatory areas related to innovation, where countries need to set rules, are: i) market competition; ii) technical standards, metrology and quality standards and accreditation; and iii) safety, health and environmental protection.

Innovation Policy Areas

Innovation policy is not a new theme for Latin American and Caribbean countries. The region has been supporting STI policies since the 1950s, but such policies have never been at the heart of competitiveness and growth strategies. Countries have evolved in terms of policy practice and institutional development at different rhythms and frequently in accordance with prevalent economic agendas and administrations.

There are some common patterns, though, in terms of the exercise of technology and innovation policy across countries. Some of the most prevalent patterns are: a lack of continuity over time; partial attention to articulation of the national innovation system (which has resulted in an underdeveloped culture of networking and lack of trust); coordination failures (the inability of private and public agents to combine innovation activities to generate positive and mutual externalities, and to reinforce private and social returns), and overemphasis on science, as opposed to a balance between science, technology and innovation.

There are three main areas of action in innovation policy: i) the "supply" oriented policies, ii) the "demand" oriented policies and iii) the "strategic oriented" and articulation policies. In essence, each of these three approaches represents a main pillar of policy concern and each one tackles key components in the building of national innovation systems. The former addresses the development of public goods for innovation, notably human capital, scientific capabilities and infrastructure; the second targets the business sector, whereas the last group centers on the development of strategic policy programs and the articulation of the national innovation systems. This last approach in particular highlights the need to design new, coordinated and more comprehensive policy programs addressing specific problems and weaknesses in sectors, technologies, group of firms or locations.

These policy approaches have been gradually implemented by countries over time. They are not substitutes for each other but rather sub-components of a broad policy strategy and they can work in complementarity to each other, depending on the country's policy concerns and targets. Policy instruments within each approach can be implemented through different institutional modalities and, naturally, in accordance with each country's institutional and policy context.

1) "Supply-side" Policies

The "supply" side policy instruments focus basically on the generation of new scientific knowledge (basic and applied) and the formation of human capital and infrastructure in science and technology. These policies include the development of university and public research centers with the right infrastructure in scientific disciplines as well as investing in advanced education and research programs in S&T. The government plays a key role in human resource development, both in terms of devising long-term strategies for human capital formation and ensuring high levels of investment in education systems.

Most of the LAC countries have "supply" oriented policies in their agendas today. In fact, this policy approach has been

the main component of public policy for innovation for a long time (since the 1950s until the mid 1980s). The traditional instruments for scientific research include: funds for science and infrastructure, subsidies, grants and research scholarships. For training of human capital in S&T, policy instruments include scholarships for doctorate and post-doctorate studies abroad and education programs in technical areas, among others.

In recent years, policy in this area has been evolving substantially. More attention is being paid to the development of domestic graduate and research programs that will be able to accommodate new graduates of doctoral studies who are returning from abroad (repatriation programs). More proactive steps are also being taken to manage talent flows across borders by designing specific policies directed at preventing brain drain and attracting the scientific diaspora (e.g. recognition of researcher career objectives and monetary incentives for research by professors, among others). The creation of centers of excellence is also attracting interest: Centers of excellence seek to position the country (or region) among the top ranking research institutions worldwide and their creation frequently involves a combination of resources, subsidies and grants, from both federal and local budgets (see for instance el "Programa Iniciativa Científica Milenio" (ICM) in Chile and the "Centro de Excelencia en Genómica" in Colombia).

However, policy mechanisms for the integration of researchers abroad are still lacking. There are few programs in the region that tie local research centers and universities to national researchers abroad. Strategies to create linkages with national researchers abroad include exchange programs, fellowships, post-graduate teaching programs, seminars and workshops, joint research programs and training (see "R@íces", "Red de Argentinos Investigadores y Científicos en el Exterior" in Argentina and "Programas de Repatriación" in Mexico).

With respect to industry insertion of researchers, work needs to be done at different levels. A better balance between applied and basic research (and also between social sciences, and hard science and engineering) in research and education programs would be useful first step towards a better matching industry needs. This does not mean completely excluding basic research, but rather striving to balance discovery-driven research and more demand-driven investigation. In addition, promoting the mobility of researchers from public institutions to the private sector through specific public-private incentive programs is a second important step in balancing the employment of human capital across the innovation system. These policy strategies include creation of specialized education programs (graduate and postgraduate) jointly conceived and/or co-financed with industry (e.g. thesis and joint research programs, sabbaticals in industry, etc.) and job creation programs for doctoral and master graduates (i.e. beneficiaries of scholarships programs) to work within companies.

There are still some countries in LAC that continue to confine innovation policy to the supply of scientific research and infrastructure, leaving innovation capabilities in the business sector unattended. The prevalence of a supply-side approach over several decades has left a deep legacy in most of LAC countries: the legacy is the predominance of "curiosity" oriented research and scientific elites, and weak or absent input from the business sector in innovation policy making. The "demand" side policy approach intends to alleviate some of these problems and is especially focused on reinforcing innovation capabilities in business.

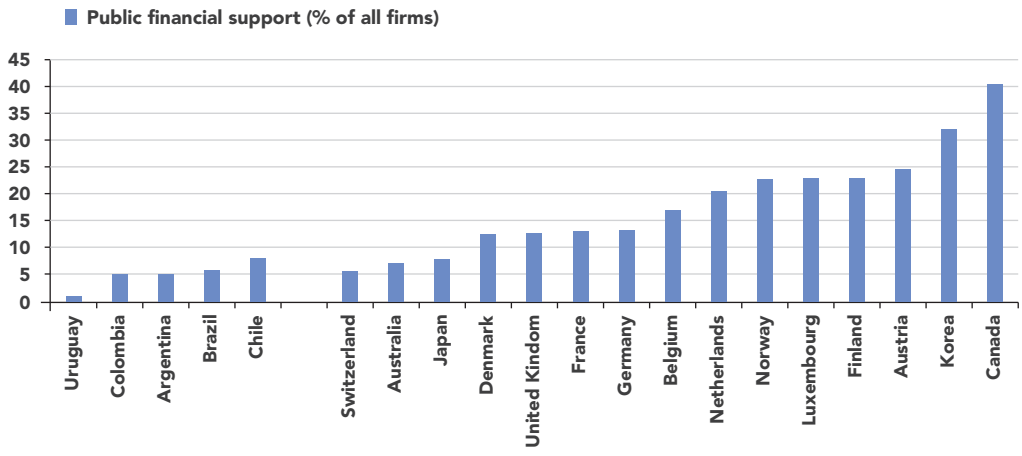
2) "Demand-side" policies

"Demand-side" policies emphasize the fact that innovation is spurred not only by scientific discovery but also by the search for solutions to practical problems in industries. Policies under this approach focus on the factors that impede investment in R&D (alleviating failures in financial markets) and more broadly, the development of innovation capabilities in firms. The chief policy targets are the generation of new products and services of high added value in firms, which lead to competitiveness and superior economic performance.

The set of policy instruments to stimulate R&D investment in firms includes: technology and innovation funds (basically providing loans and grants to firms, associations of firms, consortia and firms' research networks);competitiveness funds (credit and grants frequently associated with promotion of productivity, quality standards and exporting); fiscal incentives (R&D tax deductions);[11] venture capital (initiated mostly by public capital), and research consortia (targeting industry co-operation). Technology and innovation funds usually provide non-reimbursable loans to technological innovation projects involving small enterprises. Some of these policy programs are geared to the needs of specific industries, while others are horizontal instruments devoted to addressing needs in special areas of private sector technological development.

While several countries in the region are just starting to use these policy tools, some of these instruments, like technology funds, have reached an important level of maturity in countries such as Argentina, Brazil, Chile, Mexico and Uruguay, where they have proliferated as a family of instruments aimed at encouraging a wide range of innovative behaviors among firms. There is evidence to suggest that innovation funds can be very effective. A recent review of 13 technology funds in six countries found that, in general, the economic results are positive as evidenced by the estimated rates of return and

Figure 12 | **Percent of firms that received public support to finance innovation activities**



Notes | Indicators refer to the Manufacturing Industry. Weighted shares are reported only in the case of OECD countries.
Sources | Innovation Surveys (Colombia: 2005; Uruguay: 2006; Chile: 2005; Argentina: 1998-2001 and Costa Rica: 2008. Data for OECD countries are from OECD (2009) except for Spain and Italy (Eurostat).

[11] Tax incentives typically include: 1) reduction in the corporate income tax, 2) reduction in value-added taxes; 3) accelerated depreciation of capital goods and equipment acquired in the context of an innovation project; and 4) fiscal credits for expenses and additional investments in R&D. Fiscal incentives also include the deduction of import tariffs on certain inputs and equipment related to R&D.

the net present value. Further, there is evidence of a multiplier effect, meaning that public funds leverage private money for innovation, or at the very least, accelerate private investments (Lopez, 2009).

However, support to private firms through these types of policy instruments is frequently confined to a very small share of business in LAC countries, far from the level common in European economies (see figure 12). According to the innovation surveys, as far as public financing is concerned, 1 percent of firms in Uruguay received public funding, 5 percent in Colombia, 5 percent in Argentina, 6 percent in Brazil, and 8 percent in Chile, the highest in the region. These shares contrast substantially with the equivalent figures reported for Germany and France (13 percent of firms received public financing) and more drastically with countries such as Belgium (17 percent) or Austria (24 percent).

Lessons from programs in STI in different countries worldwide suggest that it is important to reach a balance between "supply-side" policies and "demand-side" policies. In particular, care should be taken in balancing the needs of establishing a critical mass of scientific and engineering capacity and giving incentives for private R&D (demand). In many LAC countries, it is unlikely that the private sector will take the lead in R&D at the current levels of human capital available for STI. Policies should target these two dimensions and, in some cases, in a joint manner (i.e. high level researchers and technologists for industries), as will be discussed next.

3) "Strategy–oriented" and "articulation" policies

Implementing "strategy-oriented" and "articulation-side" innovation policies involves a more comprehensive approach, which aims to address the coordination failures among the diverse actors in the innovation system and reinforce innovation capabilities in sectors deemed strategic for the country's competitiveness and social progress. "Articulation" policies are, in a certain way, instruments that help to address other market failures, such as the internalization of spillovers (by means of promotion of cooperation) and the search for innovation complementarities, the sharing of risks among firms and institutions, which combined contribute to enhance research investment by participating members and the opportunities to innovate.

This new policy orientation started in the mid-1990s in the LAC region and it basically seeks to move the emphasis of innovation policies away from a singular orientation approach rooted in either supply or demand, toward a strategic and more integrated approach. The idea behind this approach is for countries to gradually strengthen their national innovation systems so they can better assist domestic businesses in creating and applying technological knowledge to the production of more competitive products.

Within this approach, the goal of strategic oriented policies is to enable the country to develop STI capabilities in industries or technology areas that are deemed to have a significant cross-cutting economic (i.e. ICT) and social impact and/or that are key for future economic development and competitiveness (i.e., bio-fuels and other environmentally friendly technologies in Brazil). At the same time, more customized policy attention is paid to the economic sector level, in accordance with their relevance for national competitiveness and social importance (i.e. agriculture industries). Hence vertical approaches (addressing specific industries and their value chain) co-exist with more traditional horizontal ones (i.e. building S&T resources for the economy and emphasizing core strategic areas widely affecting society and progress).

Among the major instruments being used are: sectoral funds for innovation, promotion of technology networks, innovation clusters and technology parks, information systems (in STI), technology transfer centers (with broader services and not only limited to transfer of knowledge by scientific institutions, see box 2), stronger promotion and financing of university and industry innovation alliances (R&D cooperation, training and human resource mobility, licensing and start-ups), technology prospecting and monitoring, promotion of international innovation networks (linkages to global research networks and between national researchers and firms abroad), and others.

Programs organized around the notion of clusters are focusing on technology and innovation, and are increasingly combined with efforts to strengthen regional and city-centered innovation systems. In addition, explicit instances of inter-sector coordination in innovation policy have been introduced, such as industry roundtables and innovation workshops on shared research agendas, as a deliberate attempt to improve coordination and encourage pooling of resources and sharing of priorities among the key actors of the innovation system (Avalos, 2002; Navarro et al, 2010). Examples of developing innovation clusters are (Bortagaray and Tiffin, 2000): microelectronics in Campinas (Brazil), software in Guadalajara (Mexico), San Jose (Costa Rica), Rio de Janeiro (Brazil), computer science and informatics in Campinas, Sao Leopoldo (Brazil) and Monterrey (Mexico).

Another area for articulation policy is creating the informational and technology transfer infrastructure necessary for successful research and development by business. The instruments used for these purposes are: technology transfer centers (which focus essentially on the transfer of S&T competencies and provide assistance to industry), technology extension services and business incubators (notably for

Box 2 | Examples of Technology Transfer Initiatives

• **Uruguay**: Generation and strengthening of scientific and technological services
This program aims to generate and/or strengthen S&T services that respond to the demands of the productive sector, envisage solutions for social necessities in general, and improve the performance of qualified human resources. The program co-finances projects along these three lines of action, irrespective of sector. Public and private entities located in Uruguay can apply for financing and must have R&D activities among their functions and prove their potential for the provision of S&T services.

• **Mexico**: Sabbatical stays in industry by academic researchers
The CONACYT (National Council of Science and Technology) sponsors sabbatical stays for researchers and post-doctoral candidates in industry, specifically in activities related to R&D and innovation. The objective is to increase competitiveness of companies through the strengthening of technological and innovation processes. It also aims to improve the quality of human resources in companies, generate R&D projects and increase interest in the academic community for technological problem solving by firms.

• **Peru**: Centers for Technological Innovation (CITES)
A CITE is a technology partner for companies to increase innovation capacity and achieve superior competitiveness and productivity. Each CITE provides: training, technical assistance, information, assistance in productive process and quality control, computer assisted design, and technologies related to the environment. Each CITE is a meeting point for public institutions, academy and the private sector, and aims at articulating the elements of the national system of innovation of each productive chain. The goals are to facilitate and promote technological change, quality, innovation and productivity in companies, especially in SMEs (small and medium size companies) in order to compete in global markets.

Sources | Políticas e Instrumentos en Ciencia, Tecnología e Innovación en América Latina y el Caribe 2009. IDB, REDES and RICYT. Website: http://www.politicascti.net/

technology start-ups) and the financing or co-financing of intellectual property protection (financial support for application and renewal fees).

Technology transfer institutions are particularly important for technologically lagging firms in the process of "catching-up," especially small and medium size enterprises, which are frequently disadvantaged relative to larger firms in terms of access to technology and appropriate human resources in S&T. Technology transfer centers and technical institutions provide technology extension services that can help expand technological capabilities in firms by providing different kinds of expertise and services including, but not limited to: prospective studies, adaptation of foreign technologies, engineering services and development (i.e. testing of new products, calibration and quality tests) and training and networking services (i.e. with providers of technology and customers; other industries).

The rise of policy programs that target specific technology and/or industry sectors constitutes a response to the view of world class economic competencies as a product of knowledge intensive efforts in activities that promise high impact. Some of these sectors are industries or technologies in which the country's competencies are still embryonic but the sector is deemed strategic for future economic performance (semiconductors, nanotechnology; see for instance FONSOFT software in Argentina or CT-BIPOTEC in Brazil). There are also policy programs targeting sectors where countries have a competitive advantage and need to leverage performance through knowledge and innovation. Among the instruments that are promoted in this approach are: sector and technology funds (e.g. INCAGRO-FTA in Peru (agriculture); FIP (agriculture) and FIA (fishing) in Chile) and funds and other policy programs targeting cross-cutting areas.

Sectoral funds[12] are being used in the largest Latin American countries (widely in Brazil and Mexico, and just beginning in Argentina and Chile). During 2008-2009, Brazil had 14 Sectoral funds. These are frequently trusts or fiduciary funds to allocate and coordinate resources for scientific research and technology development in sectors that are highly relevant for national economies and deemed strategic for economic growth and competitiveness (e.g. fishing industries in Chile, agriculture in Argentina) and/or social development (i.e. water and health).[13]

Programs to support cross-cutting areas include the creation of funds for sustaining technology development in technologies (or sectors) having a transversal impact in the economy and society, such as ICT or environmentally friendly technologies. Cross-cutting sectors include transport and energy (e.g. CT-AEREO and CT-ENERG in Brazil; Sectoral Fund for Technology Development in Energy by CFE-CONACYT in Mexico).[14]

Priority Area Programs are basically designed to support S&T activities for social development. Activities include the mobilization of resources (human and financial) for R&D, which is frequently conducted in specialized national research centers, and the diffusion of cost-effective

[12] There is yet to be a standard definition for sectoral funds. Sectoral funding or initiatives can be, broadly, in the public or private sector, they may concern economic sectors (industries such fishing, agriculture), major public sector areas (water, transportation energy.), and in some countries, sectoral initiatives also apply to technology level sectors (biotechnology, nanotechnology). Sectoral funds can also be more specific within a particular industry sector or sector within an industry.

[13] The funds aim at channeling resources to support technological development and innovation of sectors through actions widely addressing the requirements for strengthening research capabilities: the transfer of scientific knowledge to industry, training of human resources, quality standards, etc.

[14] Brazil has two important horizontal funds: VERDE AMARELO for strengthening R&D linkage between universities and firms, and FUNTTEL, for the development of Telecommunications.

technologies with social interest. Two examples are: the FINEP-PROSOCIAL and FINEP-HABITARE in Brazil and the Sectoral Fund for Research and Development in Water CAN-CONACYT in Mexico.

Initiatives to support the creation of specialized research institutions addressing industry needs are also expanding in the region. In some countries, though, their creation dates since the early 1930s (e.g. INTA in Argentina and CENIS in Colombia). CORPOICA (Colombian Corporation for Agriculture and Farming Research) seeks to generate and transfer scientific knowledge and technological solutions to the agriculture and farming sectors. It aims at becoming the leader in research and innovation and contributes to the articulation of the national innovation system and the integration of local teams to international networks in S&T.

The results of sectoral instruments are still not evident across the region. However, there are some interesting recent examples that provide grounds for optimism. Successful sectoral policy initiatives are found in Brazil and Argentina, in the area of agricultural exports. These efforts have placed emphasis on collaborative processes between public research institutions, technology transfer and extension services and industry. A similar synergy is developing in the emerging agricultural machinery industry in Argentina (Lengyel, 2009).

Box 3 | Examples of Sectoral Funds in Latin American Countries

- **Argentina**

FONSOFT (Fiduciary Fund for the Promotion of the Software Industry): The goal is to strengthen innovation activities in the software industry. It finances innovation activities (R&D projects, training of human resources, tertiary level or higher; quality improvement programs and entrepreneurial projects) by firms through different credit lines and subsidies (non-reimbursable) to companies. Funding is conditional on being a small or medium size company dedicated to the production of software (goods and/or services).

- **Chile**

FIA (Foundation for Agricultural Innovation): this agency seeks to contribute to the building of a modern, competitive, inclusive, diverse and productive farming sector through the promotion of innovation. FIA issues competitive calls for proposals, and then promotes, coordinates and finances innovation projects and/or projects of industrial transformation or commercialization in the areas of farming, forest, agro-forest and freshwater fishing.

FIP (Fund for Fishing Research): This fund is dedicated to financing studies necessary for the adoption of new measures of management in fisheries and aquaculture activities. These measures aim at conserving hydro biological resources, taking into consideration biological, economic and social aspects.

- **Peru**

The INCAGRO program in Peru, which focuses on agriculture, promotes the provision of basic research and technology extension services for different projects along the value chain. This institution has successfully been promoting a public-private network of information in science and technology related with agriculture (AGRORED PERU) as foundational to development of an industry innovation system. In addition, the Agrarian Technology Fund (FTA), associated with INCAGRO, promotes the implementation of specialized technology services (including technical assistance and training for the application of specialized knowledge to solve problems in production, post-production and post-harvest, processing and transformation and commercialization of products) and adaptive research services (in particular, solving technical problems that limit productivity and competitiveness through the adoption and adjustment of existing technologies). The institute also channels assistance for improving management of productive units and firms.

Sources | Políticas e Instrumentos en Ciencia, Tecnología e Innovación en América Latina y el Caribe 2009. IDB, REDES and RICYT. Website: http://www.politicascti.net/

Institutional Development and Governance of Innovation Policies

The maturity and development of institutions and policies for innovation in the region varies widely. At present, a variety of instruments are being implemented in LAC countries, although there is still remarkable heterogeneity in policy priorities and availability of instruments (Figure 13). Countries such as Argentina, Brazil, Chile, Mexico and Uruguay possess a wide array of policy mechanisms whereas countries like the Dominican Republic, Guatemala or Costa Rica focus only on one or two of the elements of the national innovation system.

In general terms, in the case of human capital for innovation, all countries have at least a few instruments. By contrast, countries have fewer instruments devoted to strategic and selective policies, even in some countries that have the most developed innovation policy institutions.

The adoption of a specific approach to innovation policy and the array of instruments that goes with it are not a result of automatic decisions or plans. Experience has shown that the emergence of a new "innovation policy" approach has always come with institutional development and new governance mechanisms. A variety and combination of policy instruments requires the institutional development necessary for their functioning, monitoring and

Figure 13 | **Innovation policy instruments in Latin American countries (selected countries, 2008)**

Instrument / Country	ARG	BRA	CHL	COL	CRI	DOM	GTM	MEX	PAN	PER	PRY	SLV	URY
Supply Instrument													
S&T Funds	■	■	■	■	■	■	■	■	■	■	■		■
Support to centers of excellence	■	■	■	■				■					■
Scholarships for undergraduate, graduate and postgraduates in S&T	■	■	■	■				■	■	■			■
Support programs for national postgraduates in S&T	■	■	■	■				■	■		■		■
Salary incentives to research in S&T	■							■	■				■
Affiliation with national researchers abroad	■		■					■	■				■
Demand instrument													
Technology and Competitiveness funds	■	■	■	■	■			■	■	■	■	■	■
Venture capital and other financial funding for firms	■	■	■	■									■
Fiscal incentives for R&D	■	■	■	■					■				
Promotion of technology and knowledge transfer (extension technology services)	■	■							■	■	■		
Strategy and Articulation instruments													
Sectoral Funds	■	■	■					■					■
Priority Areas Programs	■	■	■	■				■		■			■
Innovation clusters, promotion of conglomerates, business incubators, etc.	■	■	■			■							■
Mechanisms for enhancing regional innovation systems		■	■					■					
Coordination mechanisms between actors of National Innovation Systems (technology tables, innovation chambers,...)	■	■	■					■					■

Source | Navarro et al (2010). Based on Políticas e Instrumentos en Ciencia, Tecnología e Innovación en América Latina y el Caribe 2009. IDB, REDES and RICYT, and contributions from experts. Website: http://www.politicascti.net/

evaluation. Hence the heterogeneity in policy action and instrument availability in Latin American and Caribbean countries (figure 13) reflects to a large extent the divergences in institutional development across countries.

At the start of S&T policy practice, most of the policy action was centralized at the National Councils of Science and Technology and similar agencies. The "supply" oriented policy approach which centered substantially on the development of physical and human capital for scientific research, was -- and still is in some countries -- under the management of these planning and execution agencies. With the introduction of innovation funds in the mid-1980s, these institutions had to widen their competencies (within or through the creation of new agencies) and, in addition, specialize in the management of competitive funds for innovation and research and all the tasks that these initiatives demand, including but not limited to: managing calls for research proposals, processing and evaluation of projects and selection and management of expert evaluation committees.

The advent of the strategic policy and articulation approach has brought with it the need for new institutional "governance" for innovation policies. The need for articulated policies and coordination has led in some countries to the creation of new institutional entities for the promotion and management of innovation policies. Some examples include: the creation of Ministries of Science, Technology and Innovation in some countries (in some others the elevation of national councils to the level of ministries); the emergence of a variety of innovation and competitiveness councils (akin to what the OECD has labeled the "whole government approach" to innovation), and a new orientation of S&T councils with a stronger emphasis on articulation within and among sectors. Under this approach, discussion, partnership and coordination with industry are considered key elements in the design and implementation of policies. There is a conviction among policy makers that an effort must be undertaken not only to gather the relevant information needed to nourish policy-making and implementation, but also to adjust the different pieces in national innovation systems, with input from the public and private sector. Hence, policies are viewed as a product of political consensus and coordination among actors that permits and ensures effective policy operation and consistency over time.

Some LAC countries, such as Brazil, Chile, Colombia or Argentina, have started evolving towards this institutional approach, which differs substantially from more traditional National Councils of S&T (CONICYTs). These new institutional modalities are characterized by, among other things: i) the sharing of responsibilities between: one (or a group of) executive agency(ies) concentrating expertise in the design and execution of policy instruments (e.g. technology and innovation funds, funds for advanced human capital), ii) a policy strategy group dedicated to the "articulation of the innovation strategy"; iii) an "innovation" cabinet composed of a group of ministers and commissioned to support political strategies and proposals and facilitate coordination among public entities (i.e. cabinets of this type exist today in Chile and Uruguay). The creation of these types of initiatives reflect a clear attempt among key stakeholders to partner and also works to strengthen the role of innovation policy in the strategy of economic growth and development. It aims at transforming innovation policy into a state policy, and prioritizing it in the national economic strategy.

The evolution towards more coordinated and multifaceted policies (combining horizontally and vertically focused policy programs) has been gradual and in many countries it is still in progress due to

the time and specialized skills necessary for the operation of new institutional mechanisms. In some countries, this renovation has led to the advent of new practices in research planning and competition for policy support (notably in scientific research grant competition).[15]

It is also important to note that there is no magic institutional recipe for "governance" of innovation policies. The creation of new agencies for innovation explicitly targeting the business sector or the creation of national councils assisting policy design attract interest and can be good instruments for policy design and operation. However, these are just a few institutional methods among many for addressing specific national priorities and weaknesses in innovation policy governance. The need to rethink institutional governance for innovation policy is a country-specific task. It is more about identifying the institutional mechanisms best fitted to the needs and functions of each policy framework and national innovation system. Institutional solutions depend on the peculiarities of the general institutional framework in each country, including the maturity and quality of institutions, as well as the historical, political and legal framework.

Innovation Policy Challenges and the Need for Institutional Capacity

In the end, the arsenal of policy tools available to LAC countries promoting innovation does not seem very different from the one available to OECD governments. The similarity, however, conceals some significant differences. While advanced economies have a well established institutional framework that is routinely financed and has considerable built-in management capabilities, such a framework is still in an early stage of development in most Latin America and Caribbean countries. A sudden economic or political crisis, or even the normal turnover of political appointees following an election, can leave innovation institutions weakened and scrambling to retain or recruit very scarce technical and managerial talent.

Furthermore, Latin American and Caribbean countries still must pay sustained attention and devote substantial resources to initiating and strengthening basic components of the national innovation system that developed economies can take for granted.[16] Countries in LAC face important challenges in terms of policy making, and the maturity of policies and institutions. Among the pending challenges are:

(i) The need to sustain policies over the long run. The effectiveness of some innovation policies, notably on the supply and demand sides, is only seen in the medium and long run. It takes time to build a critical mass of human resources in S&T and R&D capabilities in private firms. Countries must engage in long term national strategic planning in order to warrant continuous policy action in these domains.

(ii) The need to strengthen institutional capacity to formulate, monitor and evaluate innovation policies in accordance with the guidelines of national innovation strategies. Monitoring and policy evaluation are key elements in the policy-learning and policy-making process. They serve to inform future policies and the modification of objectives and targets based on the results of impact assessment and evidence of current policy. Evaluation and oversight are weak in most LAC countries and should become a central part of the new culture of innovation policy practice.

[15] For instance, new rules and procedures to obtain funding for scientific research, such as the need to present a research project proposal and compete in calls for grants with peer qualified review committees (per field of S&T), demand researchers and scientists to develop new competencies as well as conceiving research projects in new ways, often including how to accommodate industry participation.

[16] A notable example is the difficulty that several countries in the region have in securing adequate services and capacities in metrology, technical reviews of products, and quality certification.

(iii) In order to implement meaningful policy evaluation and learning, countries need to develop information infrastructure to monitor development in STI financed projects. Such infrastructure needs to be built into planning and budgets. Recent programs in Argentina and Uruguay emphasize institutional development and the building of data infrastructure for S&T policy making (e.g. plans for the creation of STI Observatory in Uruguay).

According to a recent study of 11 institutions managing S&T and innovation policy in Latin America (Ventura, 2010), agencies in the region have weaknesses in terms of management and operations (technological modernization is needed, notably information systems infrastructure and their adequate use), policy delivery and monitoring (see box 4).

Box 4 | Institutional Development Challenges

Among the challenges faced in a recent survey of institutions responsible for the implementation of innovation policy are (based on Ventura, 2010):

- Technological modernization (use of information systems). Although most of the institutions have introduced technologies to improve the management and control of information, the use of information systems is still limited. According to the study by Ventura (2010), with the exception of the ANII (Agencia Nacional de Investigación e Innovación) in Uruguay, which processes all tasks using electronic information systems; the rest of the countries report partial development in this area. The limited use of information systems affects the possibilities to improve access and delivery of benefits, facilitate control and management and strengthen conditions for transparency (including improving consultation by beneficiaries).

- Planning and Execution. On average, improvements have been made in these two areas, notably in countries such as Uruguay, Chile and Brazil. However, in many countries these activities are still weak or missing. Three countries (Peru, Panama and Guatemala) out of the eleven under study by Ventura (2010) did not have targets to be achieved in terms of STI expenditure (relative to GDP).

- Productive processes (promotion, processing, delivery and supervision). The degree of formalization is not the same across procedures and in general terms, the productive process varies widely across countries. The most developed procedures are those regarding reception of applications and delivery of benefits. In the productive process, two specific areas that deserve attention and represent an important challenge for institutions are: the attraction of beneficiaries and supervision (the two extremes of the "business" cycle, Ventura, 2010). These two activities differ quite dramatically across LAC countries. They rank from a total absence (in some countries) to the plentiful constitution of documented processes with modules managed by information systems (in more advanced economies).

- Improving the demand from beneficiaries will require new marketing strategies for the promotion of public policies, including more proactive approaches to identify "customers" for policy instruments. For instance, the use and coordination of policy instruments with industry associations are key elements to addressing this responsibility. Departments in charge of attention to (potential) beneficiaries and the public should have the capacity to analyze databases (business directories, economic census and surveys) and other statistical sources to identify targets and conceive the corresponding promotional strategies and events. Regarding supervision, this task implies a closer interaction with beneficiaries during the execution of activities in order to build consensus regarding good practices and acquire a firsthand knowledge about what works and what does not.

- Monitoring, evaluation and transparency. In the study mentioned above, 5 out of 8 institutions reported evaluation in programs with regularity and diffusion of resulting findings (through workshops, publications). Overall, published data about benefits, beneficiaries and related job vacancies does not gain wide distribution. Naturally, the wish to disseminate information about policy effectiveness and use, essentially involves the political will to render accounts to society and be transparent in policy action.

THE IMPERATIVE OF INNOVATION

CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

III. ICT as a Framework for Innovation and Social Inclusion

The Persistent Digital Divide[17]

A key driving force behind the creation of a knowledge economy is the exponential growth in the volume and circulation speed of information generated by the diffusion of information and communications technology (ICTs). Indeed, given that ICTs allow for a substantial decrease in the costs of information storage and transmission, their diffusion across the economy reduces the uncertainty and transaction costs associated with economic interactions. ICTs reduce the geographical distance between producers and users. Buyers and sellers located in different cities, regions and countries can share information on their needs and products, reducing information asymmetries and entry costs in markets (Perez, 2008). This, in turn, leads to an increase in the volume of transactions, generating higher levels of production for the same set of inputs; in other words, ICTs become a trigger for higher productivity levels (Chen and Dalhman, 2005).

Furthermore, ICTs increase firms' organizational capabilities to codify knowledge that otherwise would remain tacit, accelerating learning processes and reducing problems related to "organizational forgetting" (Foray, 2007). On the production side, production processes can be more easily decentralized, locating different components of the same processes in different countries based on the comparative advantages of each economy, resulting in major reconfigurations of global value chains (Lach, 2005). On the demand side, the ICT revolution, through massive connectivity between users and producers, induces a higher degree of customization of otherwise commodity products, opening new possibilities for developing countries to exploit emerging "niches" through e-commerce technologies.

ICTs are a cluster of technologies whose diffusion is affected by trends in price and income, infrastructure and the pervasiveness of network externalities. To the extent that those trends and the corresponding consumer demand are different across technologies, the performance of the region regarding the evolution of the digital divide will be also different across technologies. This section focuses on the evolution of the digital divide along three different dimensions: international (mainly between LAC and the developed world), intra-regional (among different LAC countries) and intra-national (according to income inequality within countries).

Internationally, the digital divide between the OECD and Latin American and

[17] The concept of "Digital Divide" has evolved over time. Initially the digital divide concept focused on differences (among countries, regions or families) only in the access to ICTs (normally measured in terms of the following different technologies: fixed telephone, mobile telephone, Internet, Broadband and computer hardware). However, over time the concept has been broadening to also include patterns of use which also includes unbalances in the capabilities and skills needed to actively engage in the knowledge economy. Given the lack of space the trends presented in this section mainly focus on the narrow version of the digital divide, the access dimension.

Caribbean countries persists (Table 1 and Figure 14). Although ICT penetration increased in the Latin American region over the period from 2000 to 2008, the gaps remain because, in most cases, while LAC has made progress, so too have the OECD countries. The trends in terms of access can be summarized as follows:

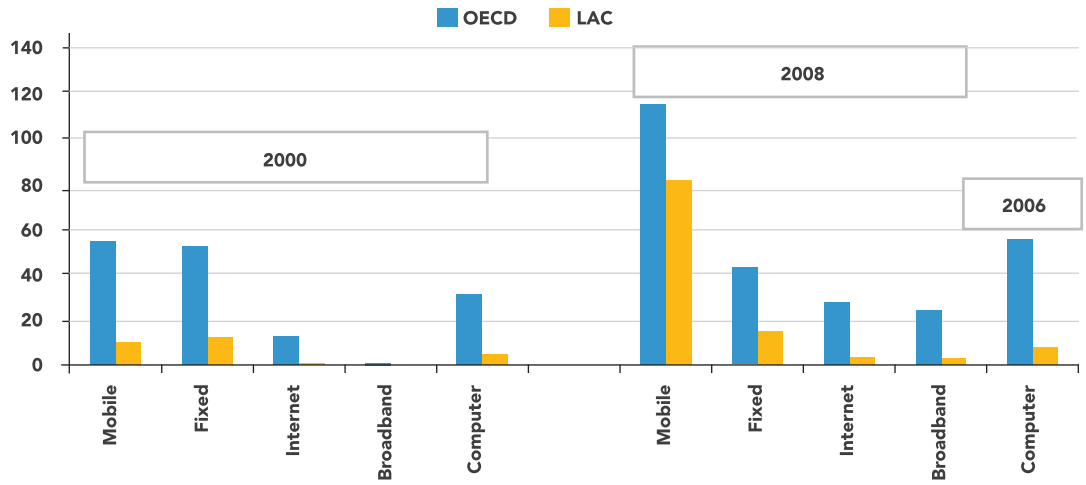
- The general trends with respect to mobile and fixed telephony indicate that for these two particular technologies the gaps are actually decreasing. OECD countries are actually experiencing an absolute decline in the number of fixed telephone lines per 100 inhabitants (from 52.4 in 2000 to

Table 1 | **ICT subscriptions per 100 inhabitants, OECD and LAC countries, 2000 and 2008 (or 2006)**

Subscriptions per 100 Inhabitants				
ICT	OECD 2000	OECD 2008	LAC 2000	LAC 2008
Mobile	54.7	114.8	9.9	81.6
Fixed	52.4	43.8	13.1	15.6
Internet	13.2	27.5	1.1	4.2
Broadband	1.4	24.7	0.03	3.4
# of Personal Computers per 100 Inhabitants				
ICT	OECD 2000	OECD 2006	LAC 2000	LAC 2006
Computer	31.8	55.1	5.0	8.7

Source | ITU statistics

Figure 14 | **ICT subscriptions per 100 inhabitants, OECD and LAC countries, 2000 and 2008 (or 2006)**



Notes | The LAC region consists of the countries for which data from 2006 were available: Belize, Colombia, Dominican Republic, Ecuador, Honduras, Mexico, Trinidad and Tobago. Mexico is included in LAC and not in OECD. Slovak Republic is included in 2000 data; it joined OECD in December of 2000. LAC and OECD regional averages are normal averages and were calculated by averaging the ITU subscription data as it was reported (per 100 inhabitants) for the countries included in the region and excluded missing data. Internet: Internet subscriptions per 100 inhabitants. Broadband: Broadband subscriptions per 100 inhabitants. Mobile:Mobile cellular subscriptions per 100 inhabitants. Fixed: Main (fixed) telephone lines per 100 inhabitants. Computer: Number of Personal Computers per 100 inhabitants.
Source | ITU statistics

43.8 in 2008), whereas LAC countries have increased the number of fixed telephone lines (from 13.1 to 15.6 from 2000 to 2008) per 100 inhabitants. This suggests that the reduction in the fixed telephony gap between OECD and LAC is due in part to an international trend of substituting fixed phones by mobile phones. In fact, both OECD and LAC regions are experiencing sharp adoption of mobile telephony. However, despite this there is still a substantial gap in both telephone technologies with respect to the OECD countries.[19]

- The LAC region has rapidly adopted mobile telephony (subscriptions per 100 inhabitants grew from 9.9 to 81.6 from 2000 to 2008, respectively). Likewise, OECD mobile adoption over the same time period was also substantial (from 54.7 to 114.8). While in the OECD mobile penetration more than doubled from 2000 to 2008, mobile penetration in 2008 in LAC is nine times what it was in 2000. The impressive increase in mobile telephony in LAC opens big opportunities for leveraging this technology to deliver business and social services.

- Regarding internet and broadband subscription the digital gap is definitively increasing. Although the LAC region has increased the number of Internet subscribers from 1.1 to 4.2 (per 100 inhabitants) between 2000 and 2008, the OECD rates of adoption also grew from 13.2 to 27.5. As a result, the absolute gap between the two regions grew from 12.1 to 23.3 subscribers. The digital gap is growing even faster in the case of broadband (due to the faster speed of diffusion of this technology in the OECD countries).

- In terms of access to computers, The number of personal computers per 100 inhabitants in growing in LAC. This is in part due to the decreasing costs of this equipment. In this regard, the region has expanded the number of computers from 5 to 8.7 per 100 inhabitants from 2000 to 2008, while the OECD countries this ratio grew from 31.8 to 55.8 per 100 inhabitants. Although the adoption of computers is growing in LAC as fast as OECD countries, given the very low starting values in LAC, the absolute digital gap between these two regions is still increasing (from 26 to 47 computers per 100 inhabitants).[20]

When analyzing the Internet divide, however, it is important to differentiate between subscribers and actual users. On average, in LAC countries there are 21.3 fewer broadband subscriptions per 100 inhabitants than in OECD countries; however when measured in terms of users (as opposed to subscribers), the digital divide in Internet decreases between the two regions (at least for the last three years). This different pattern between subscriptions and users is mostly explained by the higher relative importance of collective use (collective Internet points such as Internet "cafés", telecenters, schools, libraries, etc.) in this region compared to OECD countries (Peres and Hilbert, 2009).

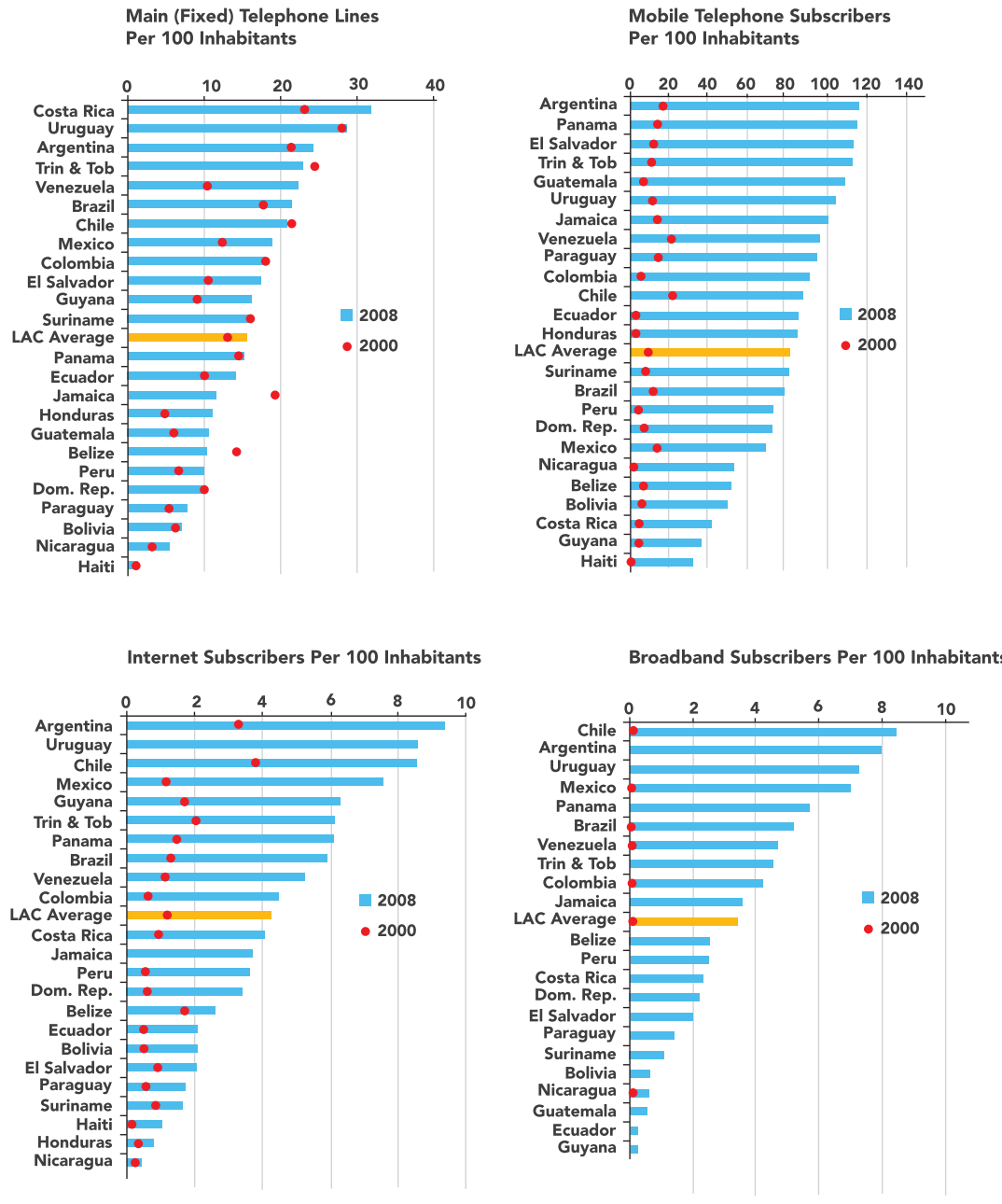
Regarding the second digital divide, the available statistics also show that there is an important heterogeneity within the region (figure 15). In Internet and broadband subscriptions, Argentina, Uruguay, Chile and Mexico are regional leaders whereas the low-income countries such as Bolivia, Paraguay and Guatemala rank among the countries with the lowest penetration.

[19] It is also noteworthy that as mobile phone technology is currently evolving very quickly (for example with the arrival of the smart-phone technology), the concept of a mobile phone itself is changing from just a simple instrument of communications to something far more sophisticated. Although overall access gaps between LAC and the OECD might be narrowing, we cannot disregard an increase in the mobile phone "quality" gap if, as expected, new mobile phone technologies are spreading faster in the OECD than in LAC.

[20] Similar to mobile phones technologies, however, it is important to note that the available international indicators for computer hardware access do not control for differences in the "quality" of the equipment, so the difference between LAC and OECD regarding information storage, processing capacities and applications may not be fully reflected in the raw numbers.

Costa Rica, Uruguay and Argentina are ahead with respect to fixed telephone lines per 100 inhabitants. Bolivia, Nicaragua and Haiti, on the other hand, have the lowest penetration of fixed telephony. In terms of mobile subscriptions per 100 inhabitants, Argentina, Panama and El Salvador lead the region whereas Bolivia, Guyana and Haiti are at the bottom.

Figure 15 | **Heterogeneity in ICT subscriptions within Latin America and the Caribbean**



Source | ITU statistics

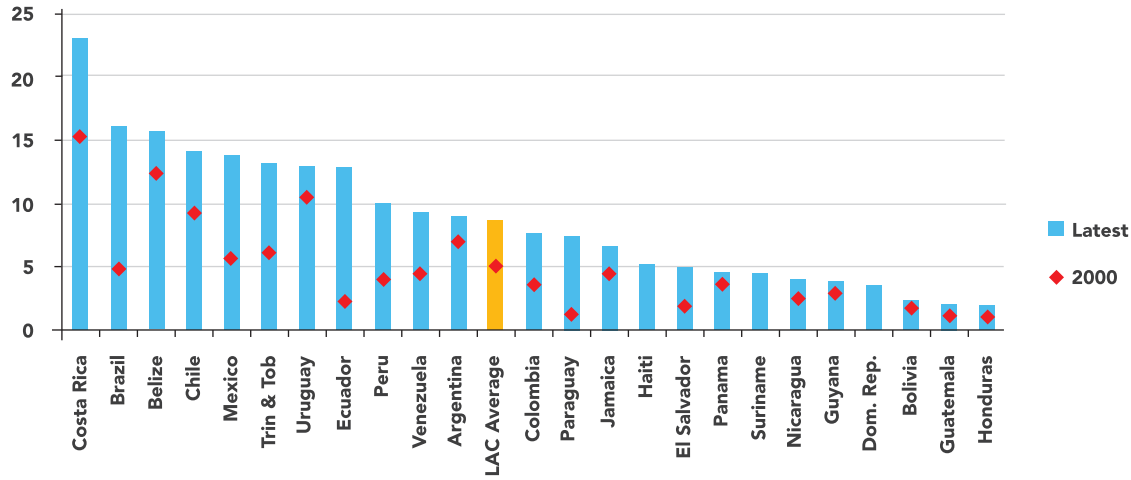
Interestingly, mobile telephony is the only ICT where Central American countries appear to have caught up with the LAC average. This suggests that barriers such as lack of infrastructure, cost and skills are less binding for low-income countries in the case of mobile phone technologies. Indeed, provided that networks exist and are available, access to mobile phone technologies requires very little initial investment (phone sets can be very cheap), access also does not necessarily require subscription (as prepaid cards are widely available in the region) and the technology is very easy to learn (and easier over time with the arrival of smart-phone technology).

A substantial disparity across countries also exists in terms of access to computers (figure 16). In terms of percent of households having a computer at home, Costa Rica, Chile, Uruguay and Brazil are the regional leaders with around 15 personal computers per 100 inhabitants. At the opposite end, the Dominican Republic, Bolivia, Guatemala and Honduras display figures of less than 5 personal computers per 100 inhabitants.

The third dimension of the digital divide occurs within countries where the diffusion of ICT technologies is also very unequal. Penetration of ICT differs substantially across income and education levels, between rural and urban areas, and across ethnic groups. This is why public access is still important in many LAC countries. Access and use of ICT is highly income sensitive, so income disparities coupled with unequal access to infrastructure and the uneven distribution of the appropriate skills means that even within countries that are closing the "macro" digital gaps, important sections of the population remain largely excluded.

Figure 17 compares the percentage of households with access to Internet at home by income level. The data for LAC countries are presented in five income quintiles. For all countries, the highest Internet penetration rates are in the fifth income quintile (the richest income bracket). As we move to lower quintiles, household income decreases, and along with it the proportion of households with access to the Internet sharply decreases.

Figure 16 | **Number of personal computers per 100 inhabitants, 2000 and latest available**



Notes | For personal computer data: latest available data for Colombia, Dominican Republic, Haiti, Honduras, Mexico, Trinidad and Tobago are from 2007; Belize, Ecuador and LAC Average are from 2006; the remaining countries data are from 2005.
Source | ITU statistics

European countries follow a similar pattern, though their data are presented in quartiles.

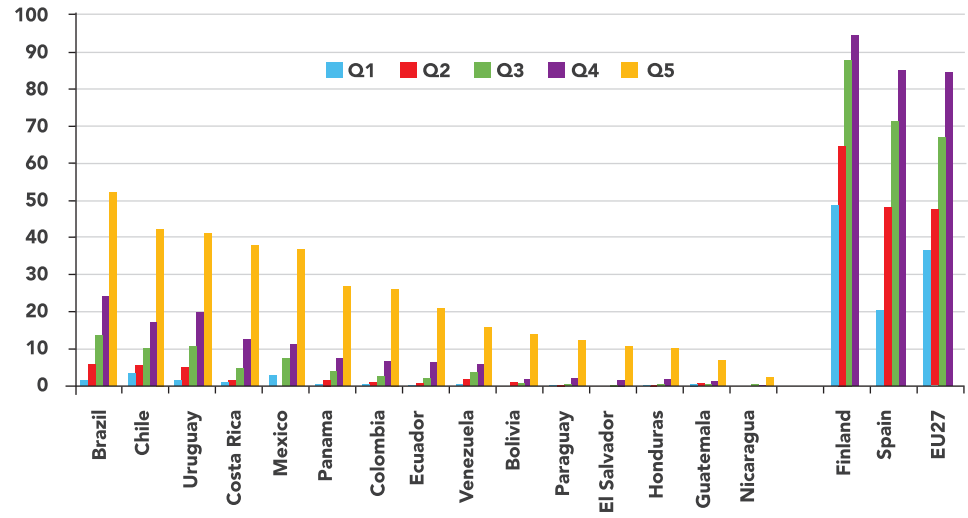
The figure reveals that households in the highest income quintiles in the LAC region (and in the countries that are the regional front runners such as Brazil, Chile, Uruguay, Costa Rica and Mexico) report roughly the same percentage of access to the Internet in the home as households in the lowest income quartiles in European countries. In countries such as Nicaragua, households, even the highest income brackets report negligible access to the Internet in the home.

Income inequality affects access to the Internet in all countries for which data is available. Yet, the disparity can be greater in countries that have weak Internet penetration overall. For example, Figure 17 shows that in Ecuador households in the highest income bracket report about 100 times more Internet access than households in the lowest income bracket. By comparison, households in the highest quartile in EU27 have two and a quarter times the access to Internet when compared with households in the lowest income quartile. Many of the countries do not report data for an earlier time period, but we can see that in LAC countries such as Brazil, Uruguay, Mexico and Chile where Internet penetration in the highest income quintile is approaching or above 40 percent (Figure 17), the inequality in the access to Internet (Figure 18) has decreased over time.

In addition to individuals and households, ICT impacts dramatically the way to do business. ICTs have drastically changed how modern businesses are conducted. In the era of the information society, ICTs can benefit enterprises through two main channels: (i) enhance firms' productivity through increasing the efficiency of internal processes; and (ii) broaden market reach, both domestically and internationally.

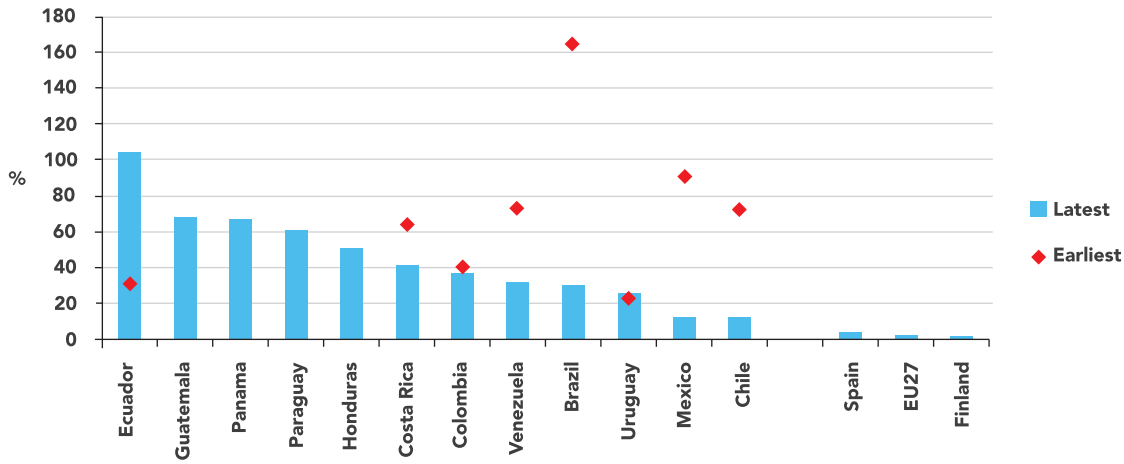
However, ICTs adoption in Latin American enterprises is still insufficient, especially in small and medium size enterprises (SMEs). Firms face several constraints when adopting ICT technologies. First, firms must sustain high fixed costs in terms of purchasing and maintaining hardware and

Figure 17 | **Percent of households with access to the Internet in the home by income quintile (1-5) for LAC or quartile (1-4) for comparison countries, 2008 (or latest available)**



Source | OSCILAC Database (secondary source; national household surveys are the primary source) and Eurostat.

Figure 18 | **Internet and income inequality: income quintile (1) divided by income quintile (5) for LAC or quartile (4) for comparison countries, earliest available and 2008 (or latest available)**



Source | OSCILAC Database (secondary source; national household surveys are the primary source) and Eurostat.

software and adapting it to new production processes, disrupting normal business practices. Second, poor telecommunication infrastructure and inadequate regulatory frameworks lead to high connectivity costs. Third, limited ICT literacy, i.e. lack of knowledge and trust in ICTs, prevents firms from adopting them and fully realizing their potential benefits. Finally, with respect to developed countries, services provided online are still limited and their regulation is embryonic, consequently reducing the attractiveness of ICT adoption.[21]

In summary, household level information indicates that a large digital divide remains regarding the adoption of ICTs in LAC; even more worrisome is data suggesting that, with the exception of telephone technologies, the gap is still increasing for the remaining technologies (Internet, broadband and PCs). The analysis suggests that two other digital gaps remain in the region. One is the gap between countries, with very few leaders at levels not very different from the least developed countries of the OECD and a large set of countries dramatically lagging behind; again in this case the exception being the widespread diffusion in the region of mobile phone technologies. The third digital divide occurs within countries, and although in this case inequality is decreasing, the region as a whole presents indicators of inequality that are still higher than in Europe. The situation regarding the business sector is different. Although the evidence here is weaker in terms of the quality of the data, available figures suggest a pattern of adoption and use in the region that is not dramatically different from what we observe in more developed countries, although somewhat delayed (see box 5).

Latin American and Caribbean governments have progressively recognized the opportunities opened by these technologies in promoting development, well-being, social inclusion and democracy. That is why an increasing number of countries have shown a growing interest in drafting and implementing public policies aimed at converting ICTs into development tools. This is the focus of the next section.

[21] One challenge in analyzing ICT penetration, adoption and use in Latin American businesses is the **lack of available data.** Only a few countries have started collecting information in innovation and industrial surveys and/or developing a new ICT survey.

Key Challenges in ICT Policy

The challenge for Latin American and Caribbean countries is not only to close the digital divide but also how to take advantage of ICT to leverage national development strategies. The utility of ICT depends on their efficient use, and that means incorporating them adequately into innovation networks, production systems and society at large. As found in several studies (e.g. Peres and Hilbert. 2009), the contribution of ICT to economic growth and more generally to society is mediated by the existence of complementarities among productive and education systems, infrastructure and institutional development, among others. In particular, having absorption capacity (skills in ICT) is indispensable for efficient adoption and use of ICTs.

Taking full advantage of the benefits of ICT for innovation and development requires the design and implementation of a set of policies aimed at targeting the most important market failure that hinders the diffusion of these technologies: the coordination failure (Aghion, et al, 2009). These types of failures are particularly important in the diffusion of technologically complex systems that are plagued by a diversity of technological complementarities among different sub-components. This applies critically to the case of ICTs. It is widely recognized that one of the major benefits from ICTs resides in the presence of network externalities where the gains of using the technology by each individual user increase with the total number of users.

Box 5 | ICT in Latin America and the Caribbean, or How to Arrive Late to a Technological Revolution

LAC`s access to new information and communication technologies has been late and partial, as illustrated by all available indicators, such as the number of personal computers, Internet access, and access to broadband. This lag is particularly important in relation to the effects of innovation on productivity. The integration of ICT into firms' operations, combined with the accelerated growth in ICT industries, is one of the main factors—if not the main factor—that explains recent productivity growth in the U.S. economy (Draca, Sadun, and Van Reenen, 2006; Jorgenson, Ho, and Stiroh, 2008). The productivity gap between the United States and Europe in the late 1990s and early in this decade seems to be highly correlated with a slower diffusion of ICT among European firms (Van Ark, O'Mahoney, and Timmer, 2008). Similarly, there seems to be a close relationship between the diffusion of ICT and the reversal of low productivity in the U.S. service sector before 1990.

The experience of advanced economies suggests that the adoption of ICT takes time to affect productivity, since for improvements to occur, the presence of hardware embedded with the new technology is far from sufficient. A vital part of the realization of the potential of ICT has been complementary investment in organization capital, understood as the reorganization of workplaces and the accumulation of skills in employees and managers (Samaniego, 2005). Considerable investment in ICT has failed to deliver returns in the absence of such complementary conditions (McKinsey, 2003). In the case of developing countries, these complementary conditions tend to be weak (Edwards, 2002).

Some exceptions among large firms that have followed good overall approaches to adopting ICT show that it is possible for Latin American and Caribbean countries to exploit the potential of ICT (Alves de Mendonca, Frietas, and de Souza, 2008). But, in general, a lack of infrastructure and relatively high costs of adoption are producing a mix that is not beneficial. The level of only one ICT adoption indicator is excellent in Latin America: the market penetration of cell phones. This is precisely a sector that has benefited from relatively lower costs for users, thanks in part to radical marketing innovations, such as the use of pre-paid phone time.

The end result is that LAC economies have been largely deprived of one of the main engines of productivity growth in the rest of the world. This is particularly the case compared to certain Asian economies, which undertook selective but highly significant early investments in ICT, including support for local ICT industry, with enormous positive pay-offs.

Source | Navarro, Llisterri and Zuniga (2010).

The achievement of these benefits, however, requires the adoption of connectivity platforms and inter-operability standards in telecommunications and information systems. For instance, the lack of policy coordination in this regard might lead to the proliferation of multiple standards so that the market could remain populated by a diversity of devices that are not compatible with one another leading to the dissipation of network externalities.

Platforms and inter-operability standards are only part of the equation. Network externalities also materialize through the co-evolution between technology on the supply side and simultaneous inventions of applications on the demand side. It is the mix between technology development and applications that unbundles the impacts of ICTs across society at large.[22] This requires policies that are also capable of reducing the transaction costs and related appropriability problems that could harm the coordination between suppliers and users. Clear coordination problems between suppliers and users might emerge in two areas: infrastructure investment and human capital development. In these two areas, users might decide that the best individual strategy is to wait until someone else makes the complementary investment in order to gain subsequent access to either the infrastructure or the human capital at marginal cost.

It is clear from the previous discussion that tackling the coordination problems that harm the diffusion of ICTs technologies in the LAC region requires a multi-stakeholder and systemic approach focusing not only on technology supply considerations (platforms, inter-operability and standards) but also on the problems affecting the demand side. Unfortunately, the region is very far from adopting this holistic government approach to ICT policy making. In particular it is possible to identify a deficit in policy coordination in the following areas: the scope of ICT policies, access policies, e-government, e-education, e-health and e-business.

Scope of ICT Policies

(i) Current ICT policies in the region show a strong bias and a dominant focus on the development of e-government (mainly regarding financial management, procurement and the management of tax and revenue systems), often ignoring the capacities of the private sector to adopt and use ICT technologies, particularly regarding the lack of specialized human capital and the very low level of "digital literacy" in the region. It is necessary to design more comprehensive policies that reach out to various segments of the population, not only in public administration but also in the private sector, and among civil society organizations.

(ii) Almost all the policies in the region focus on the support and development of the supply of ICTs with a lack of attention to the incentives for demand development and in particular to the mechanisms that facilitate the matching of demand with supply.

(iii) There is a relative lack of integration of ICT policies into the other government policies, particularly regarding the social policy sectors (health, social security, education) and local government; these are the areas where policy institutions in the region are perhaps the weakest regarding their capacities to absorb and use ICTs.

(iv) The implementation of systemic ICT policies requires strong institutional capacities; however, institutional strengthening for the design and conduct

[22] The development of applications is increasingly becoming the most dynamic segment of ICTs, while the devices themselves are becoming a sort of commodity, where a high concentration of manufacturers currently prevails. Perhaps the best example of this situation is the iPhone, with more than 120,000 different applications developed for the same model, allowing for the market entry of vast numbers of small programming firms and at the same time increasing the value of the telephone service.

of ICT policies in the region is very limited. A simple policy appraisal of LAC countries indicates that although several countries have developed "digital agendas," the frameworks for institutional governance are not clear, policy makers' technical competencies are very limited and operational budgets are restricted.

(v) There is only limited use by LAC governments of public-private partnerships for the implementation of "digital agendas." Indeed, given that the private sector generally moves faster than the public sector, it might be possible to accelerate the execution of ICT policies by outsourcing the implementation of some of them to private firms (for example, e-procurement systems could be outsourced to a private operator, which could make the investment in order to develop and operate the systems and the public actor might pay a fee based on the total transactions channeled through the system).

Access Policies

In order to equitably distribute the benefits brought about by ICTs in a society, the first challenge faced by policy-makers has been expanding citizens' access to such technologies. In fact, a high level of ICT diffusion improves the quality of available human capital in a country, increases the demand for technological goods and contributes to the democratization of political structures by providing a greater range of people with better access to information. Recognizing that private connection is too expensive to reach the poorest segments of the population, some countries of the region have set up various programs to promote collective access to ICT. Nowadays, public access centers often constitute the only possible access channel for many Latin American citizens.[23] Despite progress, however, access policies in the region still face mounting challenges, in particular regarding the following issues:

(i) The current capacity of the licensed spectrum is very close to its saturation point. The region requires much more effective management of the spectrum, both licensed as well as unlicensed, putting more emphasis on the civil use of it in order to sustain the increase in the demand.

(ii) Although there are obvious gains in access in the region, the quality of that access can be questioned. This requires widespread development of broadband networks. Lack of broadband critically affects rural communities, semi-urban areas and the low-income segments of the population in large urban centers. Market-driven private initiative by itself does not guarantee the expansion of broadband connectivity, particularly in areas where the main problem is the lack of new infrastructure. Neither traditional nor new operators will develop networks in areas of slow return on investment, unless these investments are subsidized.

(iii) In several countries, ICT consumer equipment (PCs, laptops, netbooks, etc.) are substantially more expensive than in developed countries due to the impacts of import tariffs and other internal taxes. There is some potential to increase access in the region through reducing these taxes to internationally comparable levels. This has already worked in some countries in the region such as Colombia and Costa Rica (Rodriguez-Clare, 2005).

(iv) It is also necessary to upgrade the regulation of telecommunications in the region with the aim of taking advantage of the latest technological solutions in order to foster competition.

[23] The telecenter "alone" has not been very successful in attracting large segments of the population. When this type of community access point has been linked to other institutions such as schools or libraries, however, results have been more positive. Chile and Colombia are two countries in the region that have made much progress in this area.

(v) Improve the performance of the Universal Access Funds. At the regional level, it has been estimated that these funds have disbursed less than 11% of a total of US$2.6 billion (Vidal, 2009). Regulatory authorities in the region have not been able to make use of these funds in order to foster connectivity either because of lack of technical competencies or lack of access to these resources.[24]

E-Government Policies, Including e-Education and e-Health

(i) The region requires the development of platforms for inter-operability in order to facilitate data exchange and system integration among public institutions. These platforms could have dramatic advantages not only for the internal management of the public sector but also for the efficiency of service delivery to the private sector and the public at large. Also critical is the standardization of the technical criteria for system development and data definitions (metadata).

(ii) It is also important to diffuse information and promote the use of the supply of e-government services available to the public.

(iii) In terms of e-education, it is necessary to advance with the broadband connectivity of schools (only 10% of schools in Argentina and Uruguay enjoy broadband connectivity), together with the development of learning content and platforms for accessing such content and evaluating students.

(iv) Even more important is the integration of ICTs into educational programs, as a tool to teach, to learn and to evaluate new competencies by the students. This requires putting special emphasis on the preparation of teachers.

(v) Related to e-health public policies, efforts to digitalize primary health care centers and hospitals are still embryonic. It is crucial to start with implementing the digital medical history, which is the foundation for improving the management of the health system.

ICTs in Firms and e-Business

Beyond tackling the key factors that were identified above as preventing adoption of ICTs by firms, other policy challenges are:

(i) To increase the coverage and funding of ICT extension systems focused on SMEs[25], with the aim of increasing ICT literacy among this group of firms, helping them to adapt to the new technologies and coordinating their collective demands for ICTs applications.

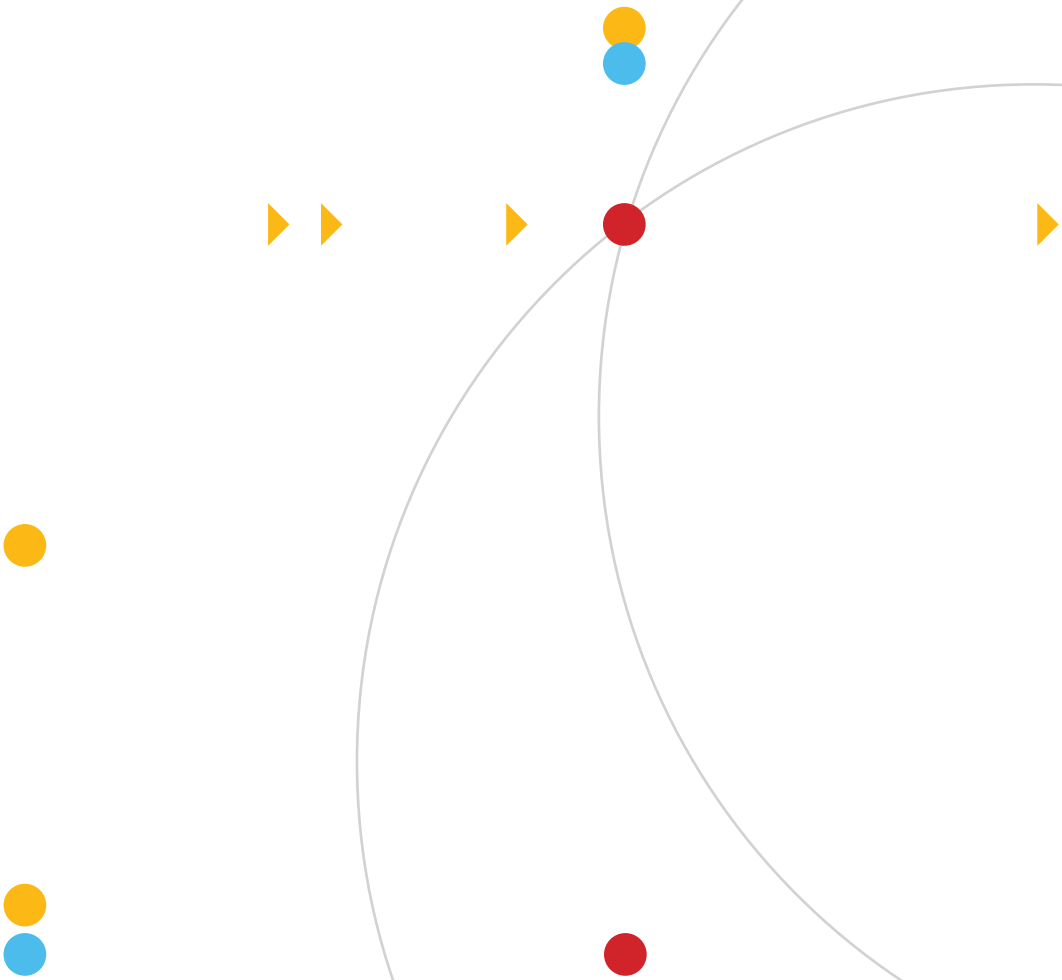
(ii) To support the development of a supply of ICT applications and services by the ICT sector with a focus on SME demands.

(iii) To work on the design and implementation of better financial instruments to make the acquisition of ICT equipment by SMEs viable (leasing, factoring, loan guarantees, tax incentives).

In order to effectively promote ICT diffusion among Latin American firms, however, specific and limited initiatives are not sufficient; it is necessary to embed them into each country's SME policy and digital agenda. Unfortunately, this rarely happens and, analyzing the issues included in the digital agendas of countries of the region, it is possible to observe an inclination towards the use of ICTs only as an instrument of social inclusion and development rather than as a factor of economic development (Peres and Hilbert, 2009).

[24] Universal Access Funds are a financial instrument managed by telecommunications regulators funded with a percentage (normally between 1% to 3%) of operators' revenues. These funds have been used regularly to extend the networks to rural or poor areas.

[25] Providers of ICTs services tend to focus on the development of solutions for large firms and traditional sectors such as Finance, Insurance, Logistics, Agro industry and Wholesale Trade, but the supply of solutions is very tiny for SME needs. Working with this group of firms is normally very complex as the group is very heterogeneous and transaction costs are very high.



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IV. STI's Contribution to the Millennium Development Goals

The United Nations Millennium Summit of the year 2000 set a series of goals that countries should aim to achieve by 2015 in order to improve the human development conditions of their populations. Since then, the Millennium Development Goals (MDG) program has provided a framework against which countries can monitor their progress regarding human development. The MDGs presents a set of 8 goals and 18 targets, of which only the last one makes explicit reference to science and technology. Indeed, Goal 8, Target 18 states: *"In cooperation with the private sector, make available the benefits of new technologies, especially information and telecommunications technologies"*(IDB, 2004).

The main two indicators established by the MDG project regarding this target are number of telephones and computers per inhabitants; however no specific target is established for any of them. As it is possible to infer from the previous section, LAC as a whole is performing well regarding the telephone indicator, both in relative and in absolute terms, but the region is still falling behind regarding the PCs indicators.[26]

More than focusing on ICTs, this section takes a broader approach, to the extent that it is clear that S&T, including ICTs, underpin the fulfillment of almost all the MDGs from the eradication of extreme poverty to ensuring environmental sustainability. Certainly, as pointed out by the task force of the Millennium Project, *"It is inconceivable that gains can be made in health and environment concerns without a focused science, technology and innovation policy. A well articulated and focused science, technology and innovation policy can also help make progress in education, gender inequality (which is often tied to education and health care) and living conditions"* (UN Millennium Project, 2005). Building sound national S&T capabilities and international cooperation should be seen as necessary, although not sufficient, conditions to achieve the MDG goals.

As noted earlier in this paper, strengthening developing countries' innovation systems is a pre-condition for sustainable development. However, the traditional policy approach to this in LAC has focused to a large extent on systems that produce innovations for which people will pay. Converting knowledge to commercial value is certainly a prerequisite for economic growth, but in some cases economic growth, although necessary, can be insufficient for poverty reduction (if wealth generated is concentrated in a few segments of society) and, more broadly, social inclusion. In the particular case of the LAC economies, faced with persistent poverty and inequality, it is *necessary to enlarge the scope of the innovation system* concept to take into consideration issues of demand segmentation and the provision of public goods for which social demands exist but private demand (and supply) is

[26] Aggregate trends should be taken with a caveat since large heterogeneity remains both between countries and also among localities within each country. Although with differences across technologies, the progress so far has been driven mainly by some large countries in region (notably Argentina, Brazil, Chile and Mexico) and some specific segments of the population within those countries.

very limited (particularly regarding public health, education and environmental issues). The fulfillment of these demands requires a complementary balance between the development of sound domestic S&T capabilities and reaping the opportunities offered by international cooperation.

The importance of this balance resides in two mismatches: between research agendas in developed countries and the particular problems that developing countries face and between adequate solutions and access. In developed countries, research agendas are mainly driven by market considerations and social needs that are typical of these societies. Following Arocena and Sutz (2006) one particular field where the mismatch between research interests in the developed countries and social demands in developing countries is particularly striking is in medical research where there is plenty of funding for cancer and cardiovascular research in comparison with very little funding for the "diseases of the poor" (malaria, Chagas, etc). This means that a substantial part of the research agenda in developing countries should be domestically driven, in light of the lack of interest or lack of problem solving capacities in developed countries. For those areas where research agendas and demands overlap, this does not mean that developing countries could automatically "profit" from the benefits of research carried out in developed countries as this research has tacit components that will have to be de-codified and might be also protected by intellectual property rights. Thus, even in those areas where adequate solutions are available, access might be forbidden or extremely expensive.

Arocena and Sutz (2006) present a taxonomy where by combining these two dimensions (research agenda bias and inadequacy of the solutions), it immediately becomes clear that the building of local research capacities in science and technology is a critical component for the fulfillment of all MDGs. Table 2 summarizes this taxonomy. The top-left quadrant of the table summarizes the space for those technologies where there are solutions in developed countries that are also adequate for developing countries' needs, in this case "only" capacities for searching and mastering

Table 2 | **Mismatches between Research Agendas, Adequacy of Solution and Developing Country Problems**

	Problems included in mainstream research agendas	Problems not included in mainstream research agendas
Adequate solutions for developing countries problems	Solutions acquired through imports or other forms of technology transfer (e.g. fertilizers)	Results of local innovation efforts (e.g. small units to obtain drinkable water)
Inadequate solutions for developing countries problems (including cost)	Solutions generated through adaptation and development of cheaper versions (e.g. small laptops for school children)	"Diseases of the poor" (under-researched diseases).

Source | Adapted from Arocena and Sutz (2006).

the use of these technologies are needed in developing countries (e.g. adoption of new fertilizers). However, this is only part of the equation, as indigenous "innovation capacities" will be needed to solve social demands in the remaining three quadrants. In some cases, the investment in these capacities might well be beyond countries' individual capacity and it might require the setting of targeted international research programs. All this serves to highlight again the urgency of developing capable national innovation systems in LAC, as well as to directly connect the priority that innovation policy has from the economic development perspective with the priority that it also has in the case of the social inclusion and equity agenda.

Under the assumption that domestic S&T capacities are consciously built and that they are properly managed in order to face social demands, the potential that STI has to support the achievement of the MDGs cannot be overestimated. On a limited scale this has begun happening in LAC. Indeed, Table 3 shows several examples where local innovation efforts – sometimes in coordination with international cooperation -- produced concrete results that are clearly aligned with the millennium goals. The three examples are in the areas of distance education, water, and renewable energy. In some cases the interventions were led and implemented by the public sector, but in others they were the result of public-private partnerships.

Similar to what happens in the case of commercial innovation, success in the case of developmental innovation requires the implementation of a research methodology where researchers, business, government, social ministries and community-based organizations interact and collaborate within an appropriate institutional framework. In other words, a systemic approach is needed in order for science and technology to become a key input for the achievement of the millennium goals and this requires carefully designed institutional frameworks and set incentives that rewards collaboration and extension rather than only blue sky research and scientific excellence.

In many countries this implies breaking the communication walls that for historical, political and cultural reasons have usually blocked the interactions between scientific and technology institutions (including policy bodies such as Research Councils and Ministries of Science and Technology) and socially focused institutions (including Ministries but also organizations such as hospitals, schools, NGOs, etc). This involves the development of new methodologies and alternative approaches that will help with the identification of social demands (that normally are locally based), its reformulation and codification in "researchable" questions and the scaling-up of the research solutions. This scaling-up requires not only investment funding but also the development of new regulations and standards (for example, the diffusion of energy efficient buildings will not happen unless a full set of regulations and standards are put into place by the corresponding authorities, which requires science and technology institutions such as civil and electrical engineering schools to work very closely with housing and public works ministries).

Table 3 | **Science, Technology and Innovation and the Millennium Development Goals**

Science, Technology and Innovation can help address global challenges and meet Millennium Development Goals			
Millenium Development Goal	**Goal 2:** Education.	**Goal 5 & Target 7c:** Improve maternal health & Increase access to safe drinking water and basic sanitation.	**Energy* & Target 1b:** Explore new energy sources & Full and productive work for all.
Role of Innovation	ICTs can increase remote access to educational resources.	Improve energy sources and agricultural technology, low cost tech for water treatment, drip irrigation and sanitation, genetic engineering, drought tolerant crops.	Innovations in wind, solar, hydrogen and other forms of energy and power that can reduce reliance on fossil fuels.
Example	Satellite Education Computers, Laptops, or cell phones, with programming or the internet can make lesson plans and homework assignments accessible to children remotely. Children may also be an entry point of ICT knowledge dispersion for others in the household.	Autonomous Potable Water Unit (APWU) designed by Uruguayan public water supply enterprise in 1992. Units are either 6, 13, or 18 meters long and can be operational within 48 hours. The units converts "dirty" water to drinkable water. Units have been used to reduce cholera and in desaster relief situations.	Eurus wind farm in Mexico. Construction of the farm was completed by Cemex and Acciona Energia in late 2009. The 250 megawatt farm is the largest in Latin America and created more than 850 direct green jobs for residents in the area during construction. The companies estimate $1.5 million will be generated annually for the region's economy and is expected to generate enough electricity for a community of 500,000 and have the largest emission reduction indices per installed capacity in the world. The investment was aprox. $ 550.5 million.**

* Not a Millenium Development Goal; but one of the five priority areas identified by the World Summit on Sustainable Development. Source (unless otherwise specified): UNMillennium Project 2005. Innovation: Applying Knowledge in Development. Task Force on Science, Technology, and Innovation.
** http://www.ecoseed.org/en/general-green-news/green-business-news/5273
*** Source for MDGoals and targets: United Nations http://www.un.org/millenniumgoals/global.shtml

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V. Bank Programs and Areas for EU-LAC Cooperation

Bank Programs in Science, Technology and Innovation

Since its establishment in 1959, the Inter-American Development Bank (IDB) has been the largest contributor of development funding and technical support for the development of science, technology and innovation in the Latin America and the Caribbean region. From 1961 to 2009, the investment in 65 science, technology and innovation (STI) projects is valued at US$2.2 billion, or close to US$5 billion if agricultural research and development (R&D) and higher education are included.[27]

The IDB's support for STI is transversal to many areas and activities of the Bank, such as: a) Education, through projects to disseminate the use of information and communication technologies (ICTs) in public schools; b) Energy, via the creation and execution of the Sustainable Energy and Climate Change Initiative (SECCI); c) Agriculture, through programs that support biodiversity and increased productivity through more intensive use of the innovative technologies in agriculture; d) Health, by the application of mobile services programs to health management; e) Water and Sanitation, through the AquaFund, a fast-disbursing fund for innovative solutions in water and sanitation, and; f) The Multilateral Investment Fund (MIF), through vehicles such as the ICT4Business program, are all directly and indirectly contributing to the overall level of support of the Bank to STI.

The Science and Technology Division

With the creation of the Science and Technology Division (SCT) in 2007, the Bank's analytical and operational capacity has increased significantly, furthering the Bank's goal to support the countries in the region in the design, execution and evaluation of larger and more complex technological development and innovation programs, including next-generation operations such as the recently approved conditional credit line for investment in technological innovation in Argentina. SCT's mission is to support LAC countries in their efforts to become knowledge-based economies through increased investment in science, technology and innovation (STI), as a means to improve productivity and reduce poverty and inequality.

SCT's main areas of operation:

(i) Investments in Science and Technology: The SCT division provides financial support for investment programs aimed at building a solid institutional, human and physical infrastructure. Loan operations typically include components that support institutional strengthening as well as increased funding for R&D to encourage and accelerate the adoption of technology and innovation by the private sector; human capital development (including scholarships and incentives to attract researchers back to their countries and stimulate brain circulation); incentives

[27] Values expressed in current US Dollars. Based on Cehelsky and Mackinnon (2006) and Bank's project database. These amounts would double if the total value of loans were considered, i.e, the IDB investment plus the local counterpart.

to increase collaboration in research; development and innovation (R&D+i) between universities and research centers and private firms, and selective support for STI infrastructure (R&D centers of excellence, metrology, ICT infrastructure, etc.).

(ii) Innovation Policies: Innovation efforts in Latin America, particularly by the private sector, must be supported by policies and incentives that create the right environment for continued productivity growth. SCT collaborates with partners in the region to ensure that innovation policies are central to their development strategies and that they are designed to address key economic and social challenges.

(iii) Innovation Systems: SCT supports countries and regions in their efforts to strengthen their innovation systems through capacity-building, human capital formation, upgrading of scientific and technological infrastructure, and promotion of clusters and networks of firms, research institutions, universities, and government.

(iv) Information and Communication Technologies: SCT assists countries in designing and implementing digital strategies, enhancing the competitiveness of the national ICT industry, accelerating the spread of broadband networks, and incorporating the ICT dimension in other sector policies, with a focus on expanding opportunities for the majority.

SCT's main instruments:

(i) Lending programs
(ii) Reimbursable and non-reimbursable technical assistance programs
(iii) Partnerships for capacity building and resource mobilization
(iv) Evidence-based policy analysis and indicators
(v) Policy dialogue
(vi) Special Initiatives

By and large, SCT's loan operations focus on the strengthening of National Innovation Systems (NIS) in LAC countries, and support investments in the areas identified above: capacity building and institutional strengthening; human capital formation in scientific and technological fields; increased funds to promote innovation efforts by the private sector; incentives for collaborative R&D+I between research institutes, universities and the private sector, and upgrading and development of technological infrastructure.

Loans in the areas of capacity building and institutional strengthening aim to support LAC countries in the development of institutional frameworks well adapted to the particular goals and nature of STI. Recent programs along these line include specific activities directed at strengthening the capacity of leading innovation agencies on issues such as mission, policy design, implementation and monitoring, internal management, human resource development, information systems, inter-agency coordination, and public-private partnerships for the identification of thematic priorities and sector-specific innovation agendas.

SCT's lending operations also cover activities related to the creation of incentives for collaborative R&D+I between research centers, universities and the private sector, as well as the planning and implementation of new instruments to support innovation by the private sector through a variety of policy tools such as horizontal matching grants programs; horizontal R&D subsidies for university-industry collaborative projects and technological-centered business consortia; instruments for technology transfer and the identification of innovative ideas (technological extension programs, technology consultants), as well as guaranteed loans and credit lines for innovation in partnership with the private and public banking systems, among others.

Loans regularly finance human capital formation in S&T fields. They target the strengthening of scholarship programs for national and international graduate studies (notably in science and engineering) as well as attempts to make universities and technical schools more responsive to industry and local needs. The latter includes the review of engineering programs in order to make them more entrepreneurial and innovation oriented (e.g. inclusion of entrepreneurship in engineering study plans) and to increase their participation in international accreditation and quality-assurance systems. Other areas in which IDB loans regularly provide support are special initiatives to improve the teaching of math and science at lower levels of education, the diffusion of good practices in technical and vocational educations, pilot programs to encourage the insertion of young post-graduates in the business sector and programs to enhance incentives for researchers.

Finally, loans for S&T infrastructure aim at the upgrading and development of the appropriate research infrastructure as well as the upgrading of facilities and competencies in metrology and quality control laboratories.

Bank operations also include a significant number of country-specific as well as regional technical cooperation projects (TCs). TCs support loan preparation and address strategic policy priorities, such as strengthening of STI institutions, intelectual property rights regimes, promoting collaborative R&D initiatives and regional public benefits, human capital formation, and use of information and communications technologies to increase productivity and inclusion. TC projects, because of their relatively small scale in terms of funding, generally seek to promote pilot initiatives that can have a demonstration effect. Table 4 highlights some recent initiatives in the areas of innovation for social inclusion, regional innovation systems and R&D capacity building.

In the field of knowledge and capacity building products, SCT's main objectives are to reaffirm itself as a knowledge leader in STI policy and to increase awareness of the crucial importance for LAC countries of positioning STI investment as a central component of their development agendas. Consequently, the Bank is committed to developing indicators of STI in all countries in the region, deepening our understanding the impact of innovation investments on productivity and employment, evaluating different STI policy instruments and institutions, and studying and sharing best practices in STI.

In addition to the project portfolio illustrated in Figure 19, the IDB, through the Science and Technology Division, is currently preparing loan operations in the Andean Region and in Central America and the Caribbean.

SCT also supports special initiatives, through its technical assistance programs, to foster and test new approaches to investment in science, technology and innovation for development. These initiatives seek to generate new business models, best practices and learning that can be mainstreamed into the Bank's lending operations.

For example, following the lessons learned from implementation of the special initiative for people with disabilities (see Table 4), the Bank's loans to Argentina and Uruguay included components aimed at leveraging technology and innovation for social inclusion.

Figure 19 | **SCT's Project Portfolio**

Table 4 | **IDB special initiatives in STI and the MDGs.**

Initiative	Objective
Mobile Citizen	This program aims to accelerate the development and implementation of mobile services to tackle acute social and economic problems in the region, with a focus on six areas: health, education, government, commerce, social protection, and employment. The program also seeks empirical evidence of the potential social and economic impact that mobile telephone can have and to identify business models for scaling up these types of projects. For further information: www.iadb.org/mobilecitizen
A World of Solutions: Innovations for People with Disabilities	Ten percent of the population (approximately 50 million people) in LAC has some kind of disability and 70% of those are unemployed or excluded from the labor force. This particular program supports implementation of pilot projects that use innovation to improve the quality of life and the economic and social inclusion of people with disabilities in Latin America and the Caribbean. For further information: www.iadb.org/innovation
Virtual Institute	The goal of this joint initiative between the IDB and Microsoft Research is to build indigenous R&D capacity in LAC in the area of ICT applications. With that purpose in mind, the Latin American and Caribbean Collaborative ICT Research Federation (LACCIR Virtual Institute) was created as a virtual network of universities from different countries in the region to fund collaborative R&D projects that advance knowledge about the development and application of information and communications technologies to advance the development of education, health, sustainable energy, and the environment. For further information: www.laccir.org
Regional Innovation Systems	The objective of this program is to contribute to a better understanding of the dynamics of Regional Innovation Systems and how they impact technology and innovation in the productive sector in Latin America. Through the study of eight sub-national regions in four countries (Brazil, Chile, Colombia and Mexico) and the implementation of pilot programs in four Brazilian states, the initiative will generate new knowledge to support the Bank's borrowing member countries in the implementation of their own initiatives.[28]

International Cooperation: Trust Funds for S&T and Innovation

Over the past 50 years, IDB has established a long standing relationship with the bilateral institutions and governments of the non-borrowing member countries, which have helped the Bank leverage its poverty reduction programs by funding and promoting innovative approaches for projects, forging partnerships and expanding the scope of development cooperation. As IDB responds to emerging development challenges, the donor community and the IDB have agreed to focus on results, strengthening grant financing in the programming process, and creating strategic thematic, multi-donor funds that target specific priority areas like innovation and the knowledge economy, water, sustainable energy and climate change.

[28] The IDB is coordinating this initiative with the Organization for Economic Cooperation and Development (OECD), which is currently working on a parallel study on European RIS, "A New Innovation Strategy for Regions", with the purpose of elaborating a joint IDB-OECD publication comparing Latin American and OECD regional innovation systems.

Trust Funds provide an important source of non reimbursable financial and technical assistance to partner countries for the implementation of different types of development programs.

They not only **leverage finance** for new initiatives (at a small scale) that can lead to more substantial funding, but they also serve as the **main instrument to finance regional public goods and regional investment programs.** The latter is particularly important for supporting capacity building in science, technology and innovation in the LAC region.

Examples of Trust Funds in Science, Technology and Innovation with countries from the European Union include: the **Italian Trust Fund for ICT for Development** (EUR 3 million) and the **Knowledge Economy Fund** (EUR 2 million).[29] Examples of Trust funds covering other areas but with implications on science and technology include among others: the **Spanish General Cooperation Fund, the Sustainable Energy and Climate Multi-donor Fund** (Italy, United Kingdom, Germany, Spain and Finland), the **Multi-donor Disaster Prevention Trust Fund** (Spain, Canada, Republic of Korea and Japan) and the Aqua Fund (Spain).

Areas for EU-LAC Dialogue and Cooperation

Regional Latin American and Caribbean cooperation in science and technology has become an issue of growing interest by policy makers and a topic of discussion in numerous meetings sponsored by agencies of different countries. In recent years, a clear political will to strengthen the region's innovation policies has been voiced at presidential summits in the Americas; the Ibero-American Summit; the Latin America and Caribbean / European Union summit (EU-LAC); MERCOSUR; the Organization of American States (OAS); UNESCO; CEPAL; the Regional Committee for Latin America and the Caribbean of the International Council for Science (ICSU); CYTED and other gatherings, as well as the Bank's own meetings.

Despite these initiatives, a well-defined agenda with specific and measurable objectives or realistic prospects for continuity over time has yet to emerge. Clearly, there is room for improvement in regional cooperation, and cooperation between Latin America and the European Union is certainly one of the key elements in this process.

Summits hosted by heads of state of both regions have promoted dialogue and revealed considerable interest in moving forward towards a shared agenda. Since the Guadalajara (Mexico) declaration of 2004, the EU-LAC Knowledge Area has begun to address the challenges of achieving cooperation in science, technology and innovation that promotes sustainable development and social inclusion. The EU-LAC summit 2006, in Vienna, Austria, influenced the subsequent Senior Officers Meeting (SOM) which reflected the interest of both regions in creating a shared space for joint research and development, mobility and innovation in areas of common interest. Likewise, the EU-LAC summit in Lima (Peru), which addressed poverty, social inclusion and sustainable development was a beneficial prelude to the summit in Madrid in May 2010, in which the central theme is innovation and technology with an orientation toward sustainable development and social inclusion.

Current European and Latin American cooperation includes participation in the Seventh Framework Program (FP7), as well as a variety of cooperation programs

[29] Examples of trust funds financed by non-European countries in the area of science and technology are: the Knowledge Partnership Korea Fund for Technology and Innovation (US$ 25 Million), and the Chilean Trust Fund for Supporting Technological Innovation in Central America and the Dominican Republic (US$ 0.40 Million)

Box 6 | Knowledge Economy Fund: a New Generation of Funding Instruments

As part of its stronger focus on science, technology and innovation, the IDB has created a new funding instrument tailored to the latest generation of fiduciary funds, the Knowledge Economy Fund. This fund is intended to highlight the importance that the Bank assigns to innovation as a key area in development policy. It was created as a multi-donor fund to attract and leverage resources from other donors that want to make international cooperation in science, technology and innovation an important part of their contribution to Latin American development, and appreciate the leverage that resources channeled through the IDB can produce. The government of **Finland** became the first contributor of Fund in 2009.

The overall objective of the IDB Knowledge Economy Fund (KEF) is to increase competitiveness and reduce poverty in Latin America and the Caribbean through the development and strengthening of National Innovation Systems (NIS) and the support to key scientific, technological and business actors, both national and regional, so that they can become fully integrated participants in worldwide knowledge networks. This goal connects the fund directly to the core mission of the Bank, by contributing to advancing both those development goals linked to competitiveness and growth and those related to social development and welfare.

Nature of the support provided and beneficiaries

The Fund is intended to become a source of flexible, non-reimbursable funding for the support of activities that promote S&T capacity and innovation. Such a source should play a catalytic role in leveraging public and private resources through the encouragement of domestic counterpart funds as well as by supporting the preparation of larger IDB lending programs.

Given its nature, it constitutes a primary source of resources for regional projects, multi-national in scope, although it is not limited to them. The Fund's intended beneficiaries will include the private sector, universities, educational and research institutions, local community organizations as well as LAC governments seeking to promote and consolidate their national and regional systems of innovation.

Types of Projects Financed

- Inclusion of science, technology and innovation in country policy and programming agendas.
- Country-focused pre-investment feasibility studies and project preparation.
- Assessments and diagnostics for building and strengthening National and Regional Innovation Systems.
- Institutional capacity building, especially in small and poor countries.
- Evaluation and feedback to build sustainable innovation systems.
- Creation or strengthening of regional networks related to the generation, adaptation, and use of scientific knowledge and technology.
- Support for the participation of national and regional institutions in global knowledge networks in scientific and technical fields.
- Competitions, calls for proposals, and special initiatives.

among higher education institutions, such as the ALFA program (see box 7); the @LIS program, which promotes the information society; the CLARA network and its high-speed interconnection with other research networks in terms of information and communication technology, and others (see box 8).

The Euralinet Programs, as well as sector-specific scientific and technology cooperation programs, some of which are sub-regional particularly in MERCOSUR or in the Caribbean, are proof of the determined desire for cooperation in both regions. At the same time, programs that favor cooperation between Latin American companies and institutions in the FP7, especially in countries with bilateral cooperation agreements with the European Union such as Argentina, Brazil, Chile and Mexico, are accumulating rich and valuable experience in technology cooperation.

An example of bilateral agreement in scientific cooperation is FONCICYT (International Cooperation Fund for Promotion of Scientific and Technology Research) between Mexico and the European Union. This fund supports joint research and ongoing projects aimed at strengthening research networks. It attempts to create conditions for Mexico to increase participation in technology and innovation research and development programs conducted by the European Research Area of the European Union. These initiatives include mechanisms for linking universities, research centers, companies and federal and state government offices in Mexico as well as in member states of the European Union.

It is noteworthy that, to the extent that research and development becomes a global process, new modes of interaction emerge, opening new opportunities for collaboration between the two regions. Another route to integration of research systems in Europe and Latin America is reflected in the current growth of important European research centers in Latin American countries. In recent years, subsidiaries of important high-level European scientific centers have opened, such as the Pasteur Institute (France) in Uruguay, the Max Planck Institute (Germany) in Argentina, and the Fraunhofer-IME (Germany) and the VTT (Finland) in Chile. It is significant that these centers are established as regional state of the art R&D laboratories and they play a role in the region that is not confined to technology transfer and training, but also integrates local research teams into large international research networks. An important result of this trend has been the repatriation of researchers, which

Box 7 | Examples of Recent International Cooperation Initiatives in Science, Technology and Innovation between Latin America and the European Union.

- **ALFA**

ALFA is a program of cooperation among higher education institutions of the European Union and Latin America. The ALFA program has the following objectives: i) to improve the quality, relevance and accessibility of higher education in Latin America and ii) to contribute to the process of regional integration, promoting creation of a joint area of higher education in the region and exploiting its synergy with the European Union.

- **ALbAN**

The ALBAN program (High Level Grants for Latin America) seeks to reinforce cooperation between the European Union and LAC in the area of education. The grants are intended to finance studies at the masters and doctoral level as well as specialized training in institutions of their choice in the European Union. The program ended in 2006 and the new cooperation program in this area is now preparing the framework of the ERASMUS MUNDUS program, which will soon be implemented.

- **@LIS2 - Alliance for the Information Society**

@LIS2 (phase 2) is a European Commission Program that seeks to promote the Information Society and to combat the digital divide in Latin America. It also seeks to improve and extend dialogue and application of new information technologies while promoting interconnectivity among research networks in the two regions. Created in 2008, the program has a budget of 31.25 million Euros, of which 22 million is financed by the European Commission.

- **EULARINET**

EULARINET (Co-coordinating Europe and Latin America Research and Innovation Networks) is a consortium of scientific institutions in Latin America and Europe that seek to reinforce bi-regional dialogue about S&T in the European Union (and associated countries) at the policy, program and institutional levels (research entities). It has three objectives: i) to promote joint identification, establishment, implementation and monitoring of mutual priorities in work programs under the FP7 program (Seventh Program Framework); ii) joint definition of policies of cooperation in S&T, and iii) the support and promotion of Latin American participation in FP7.

contributes to reversing the brain drain. There are high expectations in the region regarding the impact these institutions can have on updating local innovation systems.

Leading up to the EU-LAC summit in Madrid in May 2010, various options are being explored for the definition of a "**Joint Research and Innovation Initiative**" that could support continuity in dialogue and cooperative efforts for sustainable development and innovation in Latin America and the Caribbean and Europe.

The Inter-American Development Bank could support such initiatives, making contributions both to inter-regional policy dialogue and at the operational level.

Along the dimension of policy dialogue, the Bank can help shape a regional agenda on science, technology and innovation. The Bank has been conducting policy dialogue exercises with sector leaders across the region for over three years, resulting in a short list of themes that appear to be at the top of the regional priorities: the assessment of innovation programs and policies, the impact of technology and innovation on the social agenda and the need to deepen our understanding of the potential of technology in strategic sectors such as sustainable energy sources, agribusiness and food production, health care and education.

Energy issues that are prominent include energy efficiency, generation of renewable energy and emissions reduction. There is also great interest in: i) good practices in international cooperation; ii) the efficiency of domestic innovation systems and iii) the need to strengthen institutions. The formalization of the regional agenda could help countries in the region establish a basis for cooperation among themselves, while supporting the European Union or its member states to specify priorities and assign resources accordingly.

In operations, the Bank could reinforce its support for participation of Latin American and Caribbean companies and institutions in European programs. That is why it explicitly incorporates this international cooperation objective in the operations it carries out with Latin American countries.

Box 8 | High Speed Networks Connecting LAC and European Research

- **CLARA (Cooperación Latinoamericana de Redes Avanzadas) Network**

CLARA is an international nonprofit organization whose aim is to facilitate communication and allow users to share information by connecting academic computer networks in Latin America both intra-regionally and internationally at high speed. CLARA is connected to GEANT, its equivalent in Europe, which benefits all its members.

The ALICE Project (America Latina Inter-conectada con Europa), a continuation of the efforts developed under the CEASAR (Connecting All European and South American Researchers) initiative, committed $10 million Euros from the @LIS (Alliance for the Information Society) Program I to the cost of setting up the CLARA network in Latin America, establishing interconnectivity with Europe, and initial operations. A second tranche of support was approved in late 2008, in the amount of $12 million Euros. Both IDB and Europe are supporting CLARA with the expectation of creating a stronger high speed Internet network in LAC (CLARA) and expanded higher quality links between computer networks in Europe and LAC (GEANT and CLARA).

- **C@ribNET**

C@ribNET is a computer network similar to CLARA that fosters collaboration, research, and knowledge sharing between higher education institutions in the Caribbean, Europe and the United States. This organization was created by mandate of the CARICOM Heads of States, receiving political support from all countries. The IDB is financing the organization of this regional network, including its institutional and legal framework, initial technical and organizational training, consolidation of some of the national networks and expansion of membership in each country.

The Bank encourages international cooperation regardless of whether the focus is on its science, technology and innovation operations or on sectoral operations that include technology components such as development in agriculture, energy, health and similar sectors. It may also incorporate elements for institutional strengthening and human resources training that could facilitate bi-regional cooperation.

Given the relative scarcity of support vehicles for regional proposals, compared with what is available to support individual countries, the Bank is going to initiate a good practice review of instruments for promoting international cooperation in science, technology and innovation. In that context, the analysis of bi-regional EU-LAC cooperation will occupy a special place. The Bank is committed to looking for new financing approaches to international technology projects and to consolidating its coordination efforts with other multilateral organizations, governments and civil society entities that are prepared to contribute to this purpose.

THE IMPERATIVE OF INNOVATION

CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

Concluding Remarks

Innovation is an imperative for the development of more competitive and sustainable economies that are capable of generating the greatest well-being for all of society. For the Latin American and Caribbean region, now more than ever innovation is one of the main avenues to face the challanges of low productivity, lack of economic growth and social inequality.

Facing these challenges is not easy. As described throughout this document, the situation of countries in the region presents great challenges in terms of scientific and technology capacity and development. In a globalized world, innovation processes are occurring on an international scale. Collaboration among countries and various actors, in the public as well as private and academic sectors, is not just attractive, but it is necessary to confront the major global challenges such as climate change, development of alternative energy, access to water and sanitation, combating poverty and responding to natural disasters. Integration of international research and development networks is an indispensible element for advancing knowledge. In addition, for businesses, internationalization of innovation carries with it the expansion of knowledge and acquisition of new competencies that go hand in hand with the globalization of economic advantages and competitiveness.

Recognizing the importance of these trends and the role that international cooperation in science and technology plays in building innovation capacity in Latin American and Caribbean countries, the Inter-American Development Bank enthusiastically supports the joint EU-LAC research and innovation initiative. The IDB, historically the most important source of external financing for S&T in the region, can provide key support for these initiatives. In particular, the Bank could contribute to leveraging resources, which would make it possible to increase the scale of projects and their regional impact, while providing coordination that will enhance the management and implementation of regional cooperation programs in these areas.

Latin America and the Caribbean have been left behind in their technology and innovation capacity. This severely impedes economic development and competitiveness. International cooperation is an important and necessary step to combat these weaknesses and accelerate modernization in technology and innovation processes.

There is a lot of room to reinforce international cooperation between the European Union and LAC in terms of science, technology and innovation. The opportunities are plentiful: joint S&T activity, diffusion of new technologies and development of agricultural capacities for their absorption, policy dialogue, and institutional capacity building (including developing capacity for the implementation and evaluation of policies). The IDB seeks to contribute to these tasks and others that are deemed necessary, and contribute to reinforcing national, regional and local innovation systems as well as, consequently, strengthening the innovation capacity that is so urgently needed in Latin America and the Caribbean.

The Bank's track record as a principal source of support in the science, technology and innovation sector in Latin America and the Caribbean, as well as its capacity for large-scale financial leverage through mobilization of resources from various donors, make it the partner of choice in an EU-LAC cooperation process aimed at accelerating the region's ability to fulfill its potential and succeed in the global knowledge economy.

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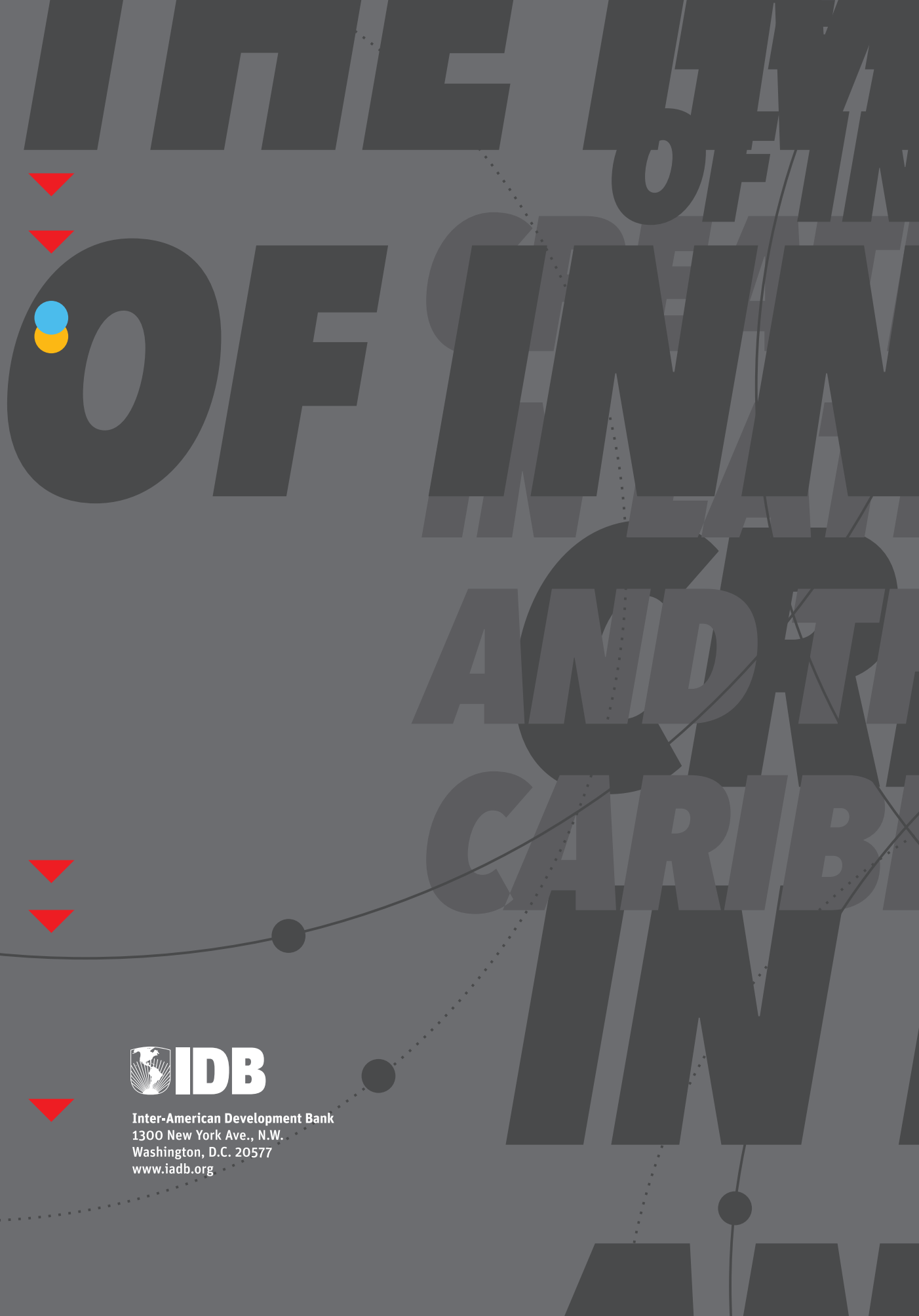

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