THE IMPERATIVE OF INNOVATION

CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

IDB

2nd Edition · 2011

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This document was prepared by a team in the Science and Technology Division of the IDB, under the responsibility and direct supervision of Flora Montealegre Painter, Division Chief. Juan Carlos Navarro and Pluvia Zúñiga had the main responsibility for writing the document, which draws from recent research 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 Compendium of Indicators of Science, Technology and Innovation for Latin America and the Caribbean (2010). Rafael Anta, Gustavo Crespi, Antonio García Zaballos, Matteo Grazzi, Carlos Guaipatin, Juan José Llisterri, Nicola Magri, and Ezequiel Tacsir reviewed the document and contributed different sections. Mikael Larsson and Alison Cathles lent invaluable research assistance. Graphic design by Círculo Salvo (circulosalvo.com) with creative support from Serrana Mujica. Comments and contributions by Hector Salazar-Sanchez are gratefully acknowledged.

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Today's economies are increasingly becoming knowledge economies. The ability and speed with which societies can absorb new technologies, access and share global information, and create and disseminate new knowledge are the main determinants of their ability to function and compete. Traces of these trends are everywhere: investment in knowledge-related activities has been growing faster than capital investment in advanced economies for at least a decade. The knowledge content of products and services is on the rise all over the world. The labor market shows a growing "skills bias" both in developed and developing economies, signaling that jobs growth will be in those occupations that involve sophisticated handling of symbols, information, and analysis. The most dynamic industries are those that can be classified as knowledge intensive, and all economic activities, even the most traditional, are increasingly influenced by technology and innovation.

Latin America and the Caribbean face the challenge of effectively embracing these transcendental changes. If the region is to create opportunities for the next generation to participate meaningfully in the global economy, science, technology, and innovation must be accorded the highest priority by leaders in both the public and the private sectors. The accelerated pace of innovation creates the need to build technological capacity in developing economies, if only to achieve the modest objective of becoming technologically literate in order to benefit from innovations originating elsewhere.

In 2010, the Inter-American Development Bank (IDB) published The Imperative of Innovation, a survey of the status of science, technology, and innovation (STI) in the Latin American and Caribbean (LAC) region. The region's technological progress was found to be uneven and insufficient, especially in relation to other regions of the world. In some cases, the region lost ground over the past 10 years in global rankings compared to some of the rapidly developing economies of East Asia. In other cases, the LAC region made progress, but so, too, did other regions. The book itself was very well received among policy makers, reflecting a growing interest on the part of its main intended audience. In a short period of time, a considerable amount of new evidence was collected as a result of a series of policy research initiatives, several of them carried out by the Science and Technology Division at the IDB, leading to even greater understanding of how innovation works in the region. This was the genesis of the second edition.

The main purposes of the second edition are to present updated information and to introduce some of the new research and policy know-how accumulated in the course of IDB lending and technical assistance operations in STI. Most of the original diagnostic remains unchanged, mostly in the initial section, although figures have been updated reflecting the most recently available data. The new figures and indicators presented in this edition are derived from the Compendium of STI indicators compiled by the IDB in late 2010. Some highlights of the second edition include:

• Further evidence of the positive effect of innovation on productivity at the firm level, including the finding that productivity gaps between innovative and non-innovative firms are larger in Latin American countries than in European countries (see particularly the beginning of Section I and Box 3).

• New data on the positive impact of technology development funds on innovation outcomes and on business performance in the medium to long term (see Box 3).

• New evidence of the complex relationship between innovation and employment, suggesting that the absence of innovation is associated with negative employment outcomes (see the special title dedicated to the issue in the first Section).

• A description of an innovative project where the Science and Technology Division used crowd sourcing and Web 2.0 tools to conduct a participatory exercise in the area of technology for social inclusion, an issue of growing interest to policy makers across the region (see Box 10).

• New evidence on gender issues in science and technology (see Box 1).

Although information and communications technology (ICT) was covered in the first edition, the second edition contains more information on the extent to which connectivity, broadband, and the telecommunications sector generally are rapidly becoming central issues for governments, firms, and citizens, along with STI and general economic policy. The infrastructure necessary to support ICT is a challenge to the region that should be addressed through new policies and public-private partnerships.

This volume reflects the IDB's commitment to remain a key partner in the development of STI policy in Latin America and the Caribbean. It is offered as a contribution to the policy debate on the critical issues involved.

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Introduction

The advent of the knowledge economy has highlighted the increasing importance of innovation and intellectual assets as sources of competiveness and long-term growth. Climate change and the limits to conventional sources of energy are challenges requiring urgent action and international coordination. Governments in the developed world recognize that increasing investment in knowledge and innovation will spur economic recovery and contribute to the development of new, sustainable economic competencies (OECD, 2009).

As they confront these global challenges, countries in Latin America and the Caribbean (LAC) region are still struggling to address national concerns, such as alleviating poverty, reducing inequality, and closing the productivity gap with respect to developed economies. The region also faces 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 long-term economic growth and development but also for the well-being of their populations.[1] It is increasingly acknowledged, at least in political discourse, that by strengthening their technological capacity, countries will be able to reorient their economies towards a virtuous circle of productivity growth, higher value-added activities, and improved living standards. Furthermore, new technologies open up new possibilities for advancing the social agenda. Information and communications technologies (ICT) provide valuable tools to enhance social inclusion through applications in education and health care and greater transparency in the provision of public services. Finally, emerging technologies such as biotechnology and nanotechnology may provide LAC economies with new tools to face global challenges such as climate change, energy efficiency, and food security.

This document outlines the conditions for innovation in Latin America and the Caribbean and discusses ways that innovation and technology can contribute to increasing prosperity in the region. It provides an overview of the current state of affairs in science, technology, and innovation (STI) and ICT compared to more developed countries. The assessments are accompanied by a discussion of the challenges that countries face in developing new approaches to the design, execution, and governance of innovation and technology policies. This discussion emphasizes the need to place innovation at the heart of countries' economic development agendas and to make it a key area of cooperation between policy makers. Finally, the document describes the IDB's programs in STI and the special initiatives launched by the Bank to promote technology for social inclusion.

[1] In its flagship publication on Development in the Americas in 2010, the IDB presents extensive empirical evidence regarding productivity, productivity growth and the importance of innovation in LAC (IDB, 2010a)

Chapter I

THE IMPERATIVE OF INNOVATION
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I. 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 of doing 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. Empirical evidence shows that about half of the variation in income levels and growth rates among countries is due to differences in total factor productivity (Hall and Jones, 1999). Previous research found that research and development (R&D) explains up to 75 percent of the differences in total factor productivity growth rates, once externalities are taken into consideration (Griliches, 1979). Evidence from OECD countries points to the fact that investment in R&D causes productivity growth and not the other way around (Rouvinen, 2002). In other words, investment in innovation is a critical input in long-term growth, rather than simply a result of that growth.

A recent IDB study examined the determinants of technological innovation and its impact on firm labor productivity in six Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama, and Uruguay) using micro data from innovation surveys (Crespi and Zuñiga, 2010). The study employed advanced econometric techniques to untangle the causal relationship between innovation and productivity. Specifically, it adapted the approach suggested by Crepon, Duguet, and Mairesse (1998) to the constraints of LAC data. In line with the findings in the literature on the industrialized world, in all countries, firms that invest in knowledge are better equipped to introduce technological advances (both new products and processes), and those that innovate have higher labor productivity than those that do not. The productivity gaps between innovative and non-innovative firms are far higher in LAC than in the European Union (EU). While for the typical EU country the productivity gap is only 20 percent, for the typical LAC country it is 70 percent. These results suggest that the region as a whole has great potential to benefit from increased investment in innovation in terms of productivity gains.

Consistent with previous findings, social returns on investment in innovation tend to be higher than the opportunity costs (returns on physical capital). For developed economies, social rates of return on 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 capacity. Innovation activities, particularly R&D investment, are fundamental for the development of new competencies and skills needed to seek, acquire, and adapt existing technology. In other words, innovation activity is a key driver of catching up (Rostow, 1960; Cohen and Levinthal, 1989).[2] It is not surprising that social rates of return on innovation are higher in developing countries. Lederman and Maloney (2003) found that the social returns on R&D 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, in the past 20 years there has been increasing interest among policy makers in discovering the main drivers of innovation. 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; Aghion and Howitt, 1992). 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 insight 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; rather, it is a collective process involving interactive learning among several actors (researchers, firms, users, etc.) and requiring multiple inputs (research, training, production facilities, marketing, etc). 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 (NIS) approach provides the framework within which governments form and implement policies to influence the innovation process.

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 continuous effort and policy coherence over time. There are considerable potential benefits to be derived from innovation in LAC countries. This leads to an obvious question regarding the extent to which countries in the region are taking the necessary steps to capitalize on this potential.

[2]Evidence has been documented on the importance of knowledge and technological capabilities for catching up (Griffith, Redding, and Van Reenen, 2002). This was 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 is associated with previous concerted efforts to build technological capacity (Kim, 1997).

Comparative Performance of Science, Technology, and Innovation in Latin America

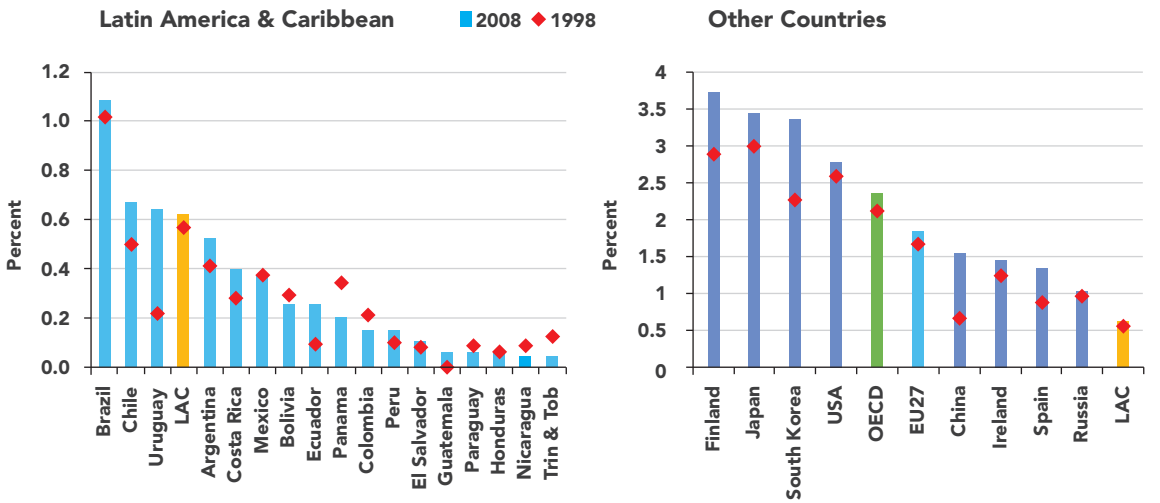
Two sets of measures are normally used to benchmark the performance of innovation systems. The first set, which consists of inputs needed for innovation (e.g., expenditures in R&D and the number of researchers), captures innovation-related investment efforts. The second set, which consists of output indicators (e.g., scientific publications, patents and technology exports), measures the effectiveness of innovation investment. 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 relevant dimension of the STI landscape, LAC countries differ greatly from more advanced economies. Overall, LAC countries display substantial underperformance with respect to OECD and EU countries and to emerging economies such as China, India, and some Central European countries.

While from 1998 to 2008 R&D expenditures as a share of GDP (R&D intensity) grew consistently in the advanced economies, improvements in LAC countries were modest on average (Figure 1). According to RICYT (*Red de Indicadores de Ciencia y Tecnología*)

Figure 1 | **R&D Expenditure as a Percentage of GDP 1998 (or Nearest Available) and 2008 (or Latest Available)**



Sources | OECD Main Science and Technology Indicators 2010 and RICYT.
Notes | There are two scales, one for each group of countries. The earliest data available for Nicaragua are 1997, for Brazil and Honduras 2000, and for Paraguay 2001. The latest data available for Bolivia and Nicaragua are 2002, for Chile, Honduras and Peru 2004, and for Mexico 2007. Data for OECD Total and EU27 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 providing lengthy technical details so as not to burden the document. See IDB (2010b) available at: www.iadb.org/tech for complete details on every source, label, and country grouping. In the case of updated data, full details are available upon request.

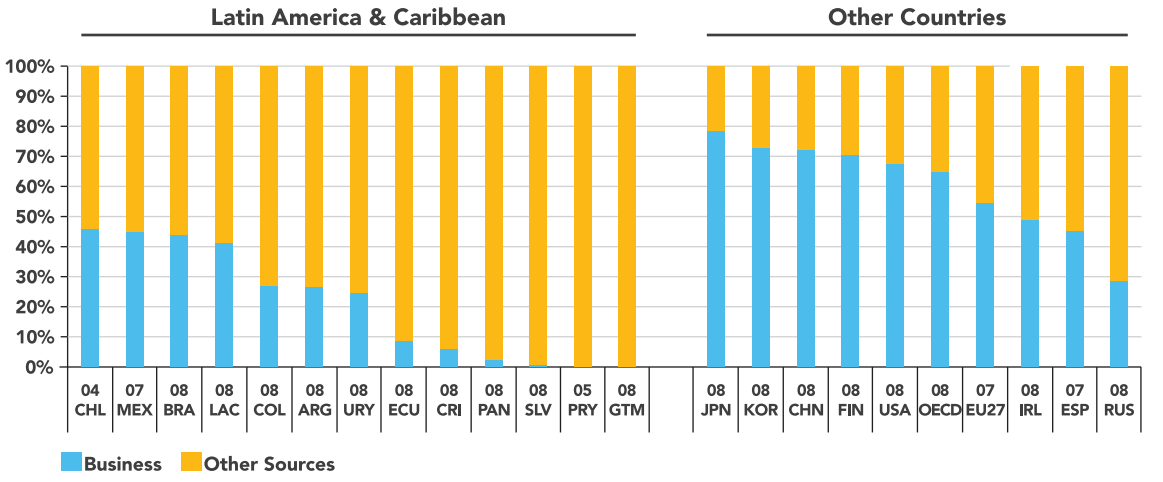
estimates, R&D investment in the region in 2008 represented 0.62 percent of GDP compared to 0.57 percent in 1998. During the same period, OECD countries increased R&D intensity from 2.1 to 2.3 percent. In addition, in contrast to the increased investment in most developed economies, efforts to improve R&D investment in LAC were concentrated in a handful of countries. Sixty percent of R&D expenditures in the region in 2007 occurred in Brazil (IDB, 2010b). R&D intensity in Brazil has reached 1.09 percent of GDP and is the highest in LAC.

Most Latin American countries still underperform with respect to other countries with comparable income levels in terms of R&D intensity. Within LAC economies, the R&D gap with respect to their potential, measured in terms of expected R&D intensity relative to national income, has been smaller in Chile, Uruguay, Costa Rica, and Brazil — between 40 and 50 percent and greater in countries such as Guatemala, where the gap is nearly 100 percent. (IDB, 2010b). At the opposite end, European innovation champions such as Denmark, Sweden, and Finland appear frequently as dramatic outperformers, with R&D intensities above what their income level would predict (Lederman and Maloney, 2003; IDB, 2010b).

Another characteristic of the LAC region is scant private sector participation in innovation efforts (Figure 2). The financing of R&D (and performance) continues to be highly concentrated in public institutions (government agencies and universities), averaging 59 percent of the total effort, compared to 35 percent in OECD countries.

The differences with respect to 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 substantially fewer Ph.D.s in science and technology per capita. There were also substantially fewer doctoral graduates per capita in the LAC region in 2007 compared to the United States and Spain. On average, there are 2.5 Ph.D.s per 100,000 inhabitants in

Figure 2 | **R&D Expenditure by Funding Source, 2008 (or Latest Available)**



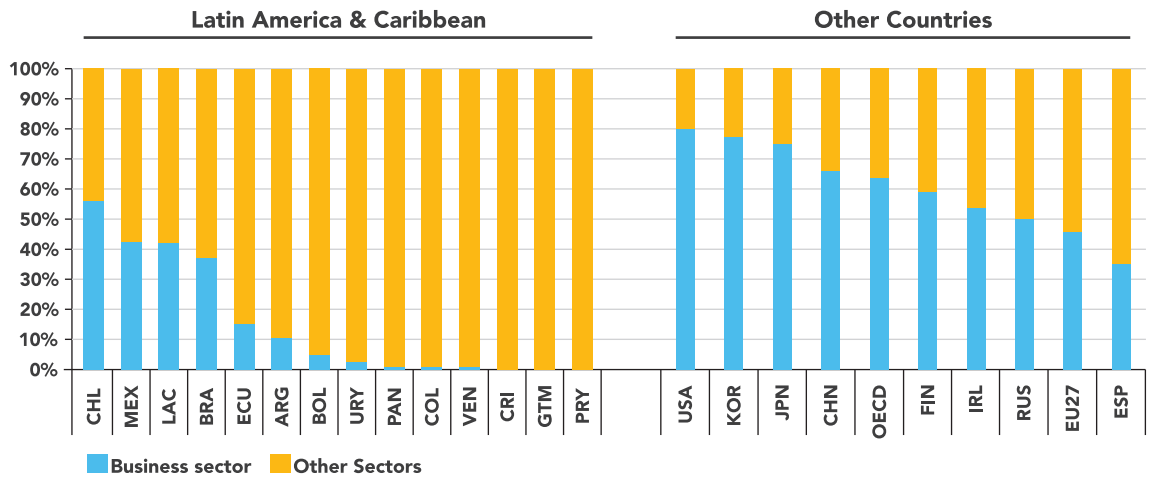
Sources | OECD Main Science and Technology Indicators (2010) and RICYT.
Notes | Government, Higher Education, Private Non-Profit, Foreign and Other have been grouped together as "Other Sources." LAC data are estimated by RICYT.

LAC and only 1.6 of those are in science and engineering, whereas in the United States and Spain there are 18.8 and 14.8 Ph.D.s per 100,000 inhabitants, respectively and, of those, half are in science and engineering (IDB, 2010b).[3] Moreover, serious issues persist in terms of incorporating female researchers into the academic profession (see Box 1).

Fewer researchers are employed in business (40 percent on average) in LAC than in OECD countries, where 64 percent of researchers are in business (Figure3). This low participation is explained by a combination of factors, including inadequate mechanisms for market insertion, the orientation of research competencies in many cases toward basic research, a mismatch between supply and demand (i.e., lack of relevance or applicability of specialties to industry needs), and particularities of institutional settings that preserve the separation of research and education systems from the private sector (i.e., 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 purchasing existing technology rather than promoting the endogenous generation of new ideas, neglecting the importance of developing research capacity for the absorption of technology. Consequently, the region's universities produce researchers and skills that are not used in industry.

The nature of research in LAC economies is also different from that in OECD countries (Figure 4). There is less applied research, notably in engineering and technology. The share of researchers working in engineering and technology as a percentage of total researchers is between 10 and 30 percent, whereas in countries such as Japan or Korea this figure is 60 percent. In a number of LAC countries, there are more researchers in the social sciences and the humanities than in agricultural sciences or engineering and technology.

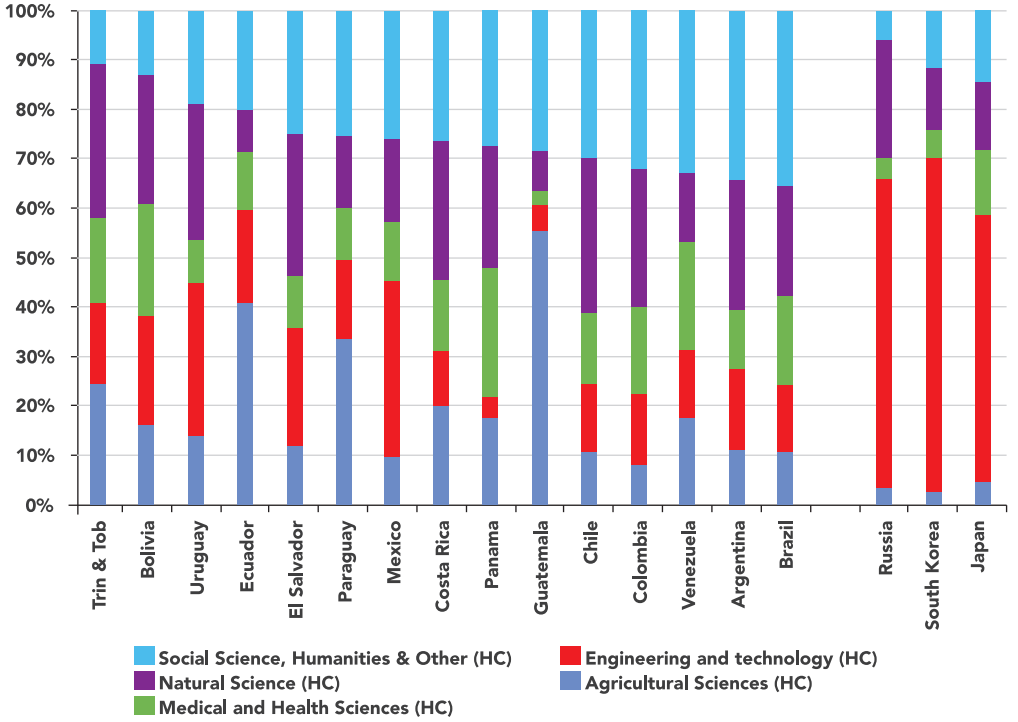
Figure 3 | **Researchers by Sector of Employment, 2008 (or Nearest Available)**



Sources | OECD Main Science and Technology Indicators (2010) and RICYT.
Notes | Government, Higher Education, and Private Non-Profit have been grouped under "Other Sectors." The latest available data for Bolivia are from 2002, Chile from 2004, Paraguay from 2005, Mexico from 2007, and OECD and the United States from 2007. The threshold for data depicted is 2002.

[3] Figures depicting Ph.D. graduates and science and engineering Ph.D.s are not provided in this paper but are available upon request (IDB, 2010b).

Figure 4 | **Distribution of Researchers by Field of Science 2007 (or Latest Available)**



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

Figures 1 to 4 highlight not only the large differences between LAC and OECD countries, but also the striking heterogeneity within the LAC region itself. A closer look at the data indicates that Brazil—and to some extent Argentina, Chile, and Mexico—have begun to evolve toward developing a technological profile closer to that of advanced economies, while the rest of the region still lags 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 differences in economic structures between developing and advanced economies. According to this argument, 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 resource sector and other sectors that are characteristic of the region. Thus, rather than indicating 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, by looking at the R&D intensity by sector rather than at the aggregate level, the conclusion of low technological intensity holds; thus confirming the existence of an innovation shortfall in the LAC countries for which this type of analysis is possible[4] (Maloney and Rodriguez-Clare, 2007; IDB, 2010b).

[4] Lack of available data prevents a disaggregated analysis of this kind for all but a few LAC countries.

For example, comparing Chile and Australia in the mining sector, and Chile and Finland in the paper pulp sector, Benavente and Bravo (2009) find that lower R&D investments in Chile account for much of the difference in productivity. Over the long term, a commitment to technological change and more technology-intensive industries may steer economic structures towards knowledge- and innovation-intensive activities, raising productivity and economic growth.[5]

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

Scientific performance in LAC countries 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). On a normalized scale of 170 countries, between the mid-1990s and the mid-2000s, the region improved its position slightly (Figure 5).

Box 1 | The Gender Gap in Science

Women have historically been underrepresented in academic fields throughout the world. The LAC region is no exception, although recent indicators provide an encouraging picture. According to UNESCO (2010), Latin America and the Caribbean reached a share of female researchers as a share of the total number of people employed in research of 45 percent in 2007, surpassing all other regions for which data is available, including Europe (33.9 percent), Oceania (39.2 percent) and Asia (18 percent).

The region presents important heterogeneity. Venezuela, Uruguay, and Argentina surpassed the 50 percent mark, while in 9 out of 19 countries, including Brazil more than 40 percent of researchers are female. In contrast, in Chile and Honduras, fewer than 30 percent of researchers are female.

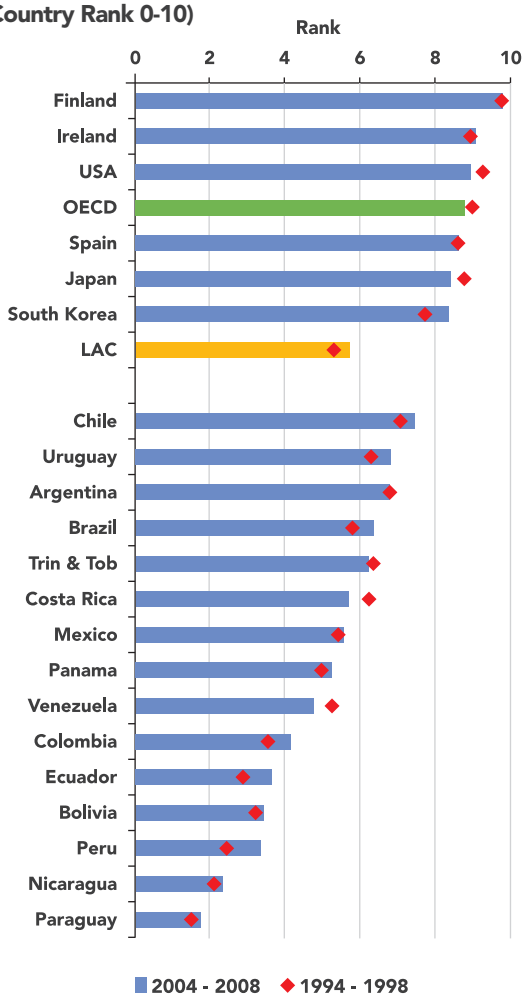
Despite these improvements, gender differences in productivity and position on the academic ladder still persist. Regional averages show that while women represent 60 percent of all tertiary education graduates, they represent only 36 percent of tertiary education graduates in science, technology, engineering and math (STEM). In fact, only 11 percent of Latin American women graduating from tertiary education are in STEM fields.[6] In Argentina, STEM disciplines account for 17 percent of all university graduates but only 9 percent of female university graduates (Tacsir, 2010). In addition, women's presence in the higher strata of research is rare, suggesting long-standing problems in the academic profession. In 2005, the Argentinean CONICET listed 57 percent of women in the lowest category of research positions, but this share decreases continuously at progressively higher levels, reaching 17 percent at the highest level. Similarly, only 10 percent of members of the National Academies are women (Baringoltz and Posadas, 2008).

Several factors are usually mentioned to explain the factors behind women's underrepresentation in scientific careers and research in general, and specifically at the higher strata of the scientific ladder. These include structural career obstacles that men manage to escape: the absence of role models, especially in the higher ranks of the hierarchy, isolation as minorities in traditionally male-dominated disciplines, an undervaluing of the contributions of women in science, and traditional cultural perceptions about the role of women (Corley, Bozeman, and Gaughan, 2003).

[5] Cimoli et al. (2006) analyzed structural change in the economic structure of Latin America between 1970 and 2000 and compared it to South Korea, Finland, and the United States. They found that growth in South Korea and Finland is associated with 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 Latin American countries, evidence shows a reduction in the participation of high-technology sectors in favor of natural resource-intensive sectors. The recent worldwide boom in commodities has probably added pressures that reinforce trends like the one described in this study.

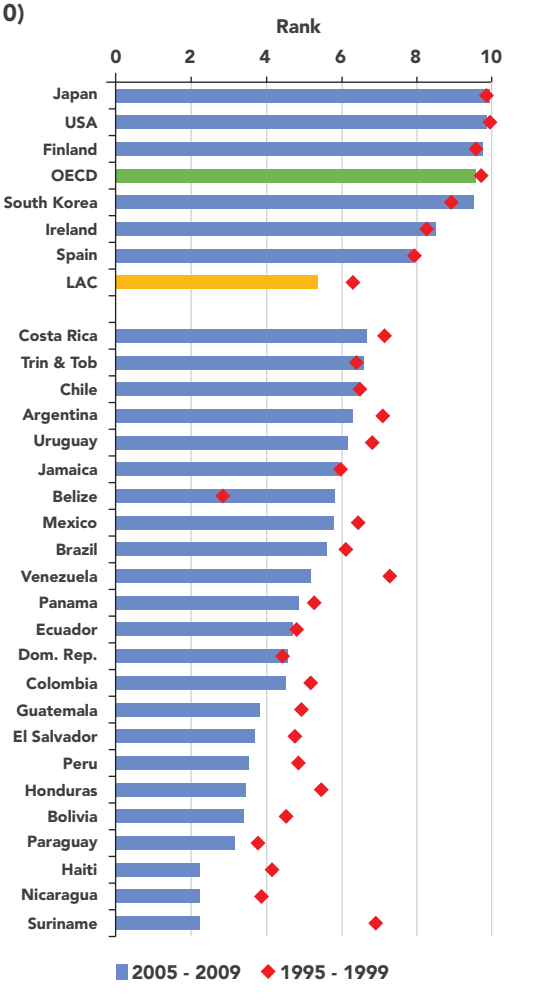
[6] Own elaboration using UNESCO database.

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 Development Indicators (World Bank).

Figure 6 | **Patents per 100,000 Inhabitants, 1995-1999 and 2005-2009 (Normalized Country Rank 0-10)**



Sources | USPTO and World Development Indicators (World Bank).

The picture is more varied if one looks at the figures for Brazil, Argentina, and Mexico, countries that rank among the top 50 in terms of scientific publications.

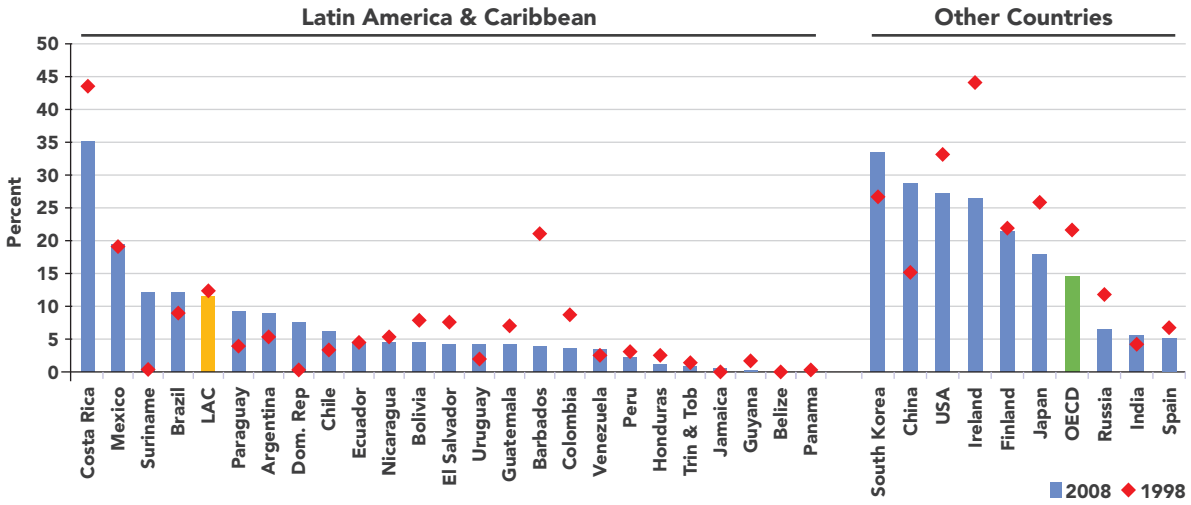
The same is true with respect to the rate of growth of publications from Latin America, which has tripled over the past decade and a half, outpacing other regions and consequently reducing the gap in this regard.

Despite some achievements in scientific performance, the technological performance of the LAC economies has remained extremely poor.

The LAC region's ranking in number of patents has fallen (Figure 6): on a scale of 0-10, LAC fell from 6.3 to 5.4 in about a decade (see Figure 6). Patents per 100,000 inhabitants reached 18 for South Korea in 2009 (U.S. Patent Office), while less than 1 per 100,000 were granted 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).

Figure 7 | **High Technology Exports (Percent of Manufactured Exports) 1998 and 2008 (or Latest Available)**



Source | World Development Indicators.
Notes | Latest available data for Honduras, Nicaragua, Korea and Spain is from 2007. For Bolivia, 1997 data were used.

Scientific Specialization

Despite the disappointing general trends, there is some good news. Over the years, the LAC region has managed to build scientific capacity in four major fields: microbiology, environmental ecology, agriculture, and plant and animal sciences. A country is specialized if it has a higher intensity of scientific production (in terms of publications) in a given field than the world average in the same field; an index greater than one indicates specialization.[7] In Figure 8, the areas with stronger specialization are those with the sharp spikes, indicating levels of specialization above 1.5.

The region has less relative scientific capacity in more "horizontal" sciences (that is, sciences with a cross-sectoral impact) such as engineering, materials and computer sciences, and multidisciplinary research. Having scientific competencies in these areas is important, as these fields leverage scientific productivity in other areas. This is particularly the case for computers and, recently, for materials science. This is particularly relevant given the range of opportunities offered by nanotechnology.

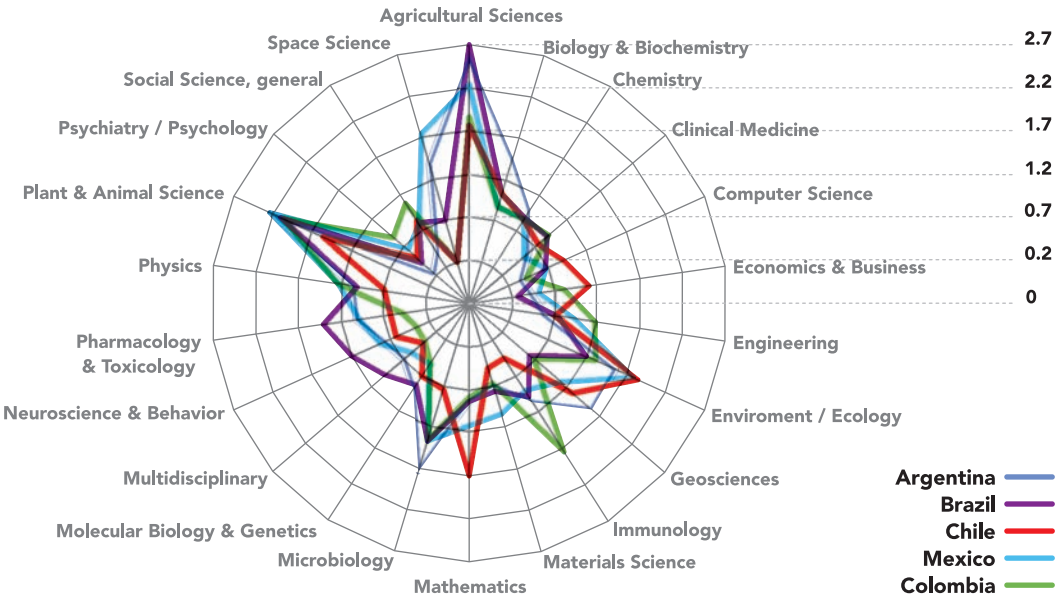
Innovation in Firms

At the firm level, innovation means transforming ideas and knowledge into economic advantages such as higher productivity growth, 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 reveals the weaknesses at the national level in terms of STI. Most firms are still far from the technological frontier, and innovation strategies are essentially oriented to the acquisition of foreign technology and its integration into indigenous production systems. As a result, innovation outcomes are not novel and are focused mostly on "adaptation" activities, that is, acquisition

[7] Or where P = papers
[(∑Pin a field in country x/∑Pin country x)/(∑Pin a field / ∑Pin the world)]; an index of greater than one indicates specialization .

Figure 8 | **Relative Scientific Specialization in LAC Countries**



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

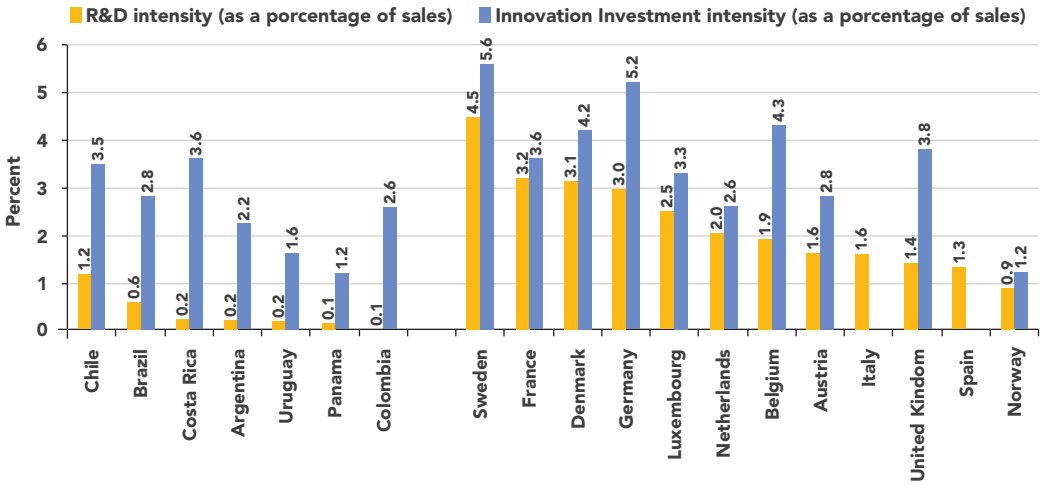
of knowledge or technologies that are new to the firm but that already exist in local or global markets (Navarro et al., 2010; IDB, 2010a).

Firms in LAC have 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 9). On average, firms' R&D intensity (expressed as a percentage of sales) is below 0.4 percent, considerably lower than the 1.61 percent European or the 1.89 percent OECD averages. As shown in Figure 9, the differences between LAC and OECD countries in terms of intensity of innovation investment by firms are less pronounced given the broad definition of innovation activities.[8] A second feature is the high concentration of innovation effort on the purchase of capital goods and equipment related to innovation activities (Figure 10). Expenditure on these items represents between 50 and 80 percent of total expenditure on innovation, while the corresponding share in OECD countries varies between 10 and 40 percent. In OECD countries, R&D expenditure is frequently the main item of innovation investment. Most 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.

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 in catching up and advancing toward the technological frontier, the impact of embedded technology at the firm level is limited if internal absorptive capacity (in the form of R&D investment or human capital dedicated to innovation activities) is absent. Innovation surveys provide further

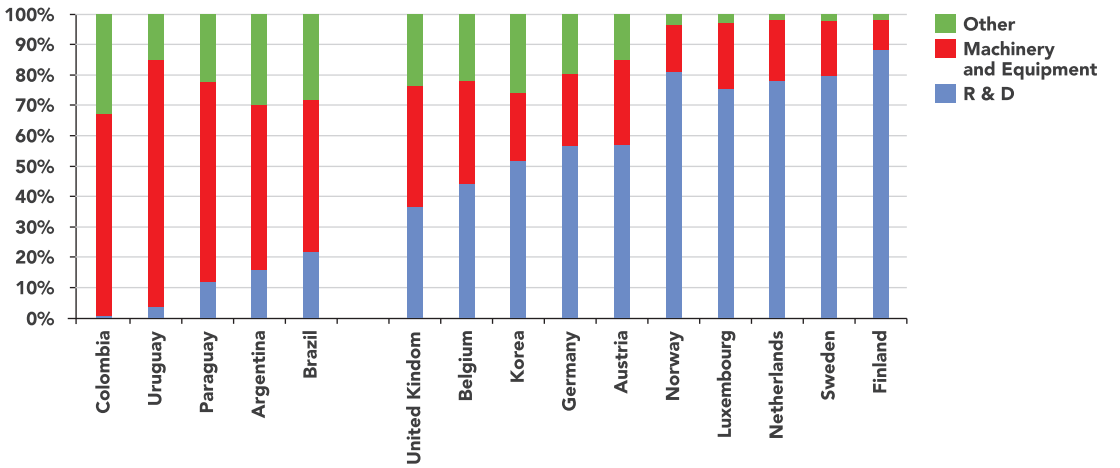
[8] Following the Oslo Manual, innovation activities include the acquisition of technology embodied in capital goods and equipment, hardware and software, the contracting of R&D services, technology transfer activities such as acquisition of disembodied technology (licensing and buying of intellectual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

Figure 9 | **Investment in Innovation by Firms**



Source | Innovation Surveys (Argentina: 1998-2001; Brazil: 2005; Chile: 2004- 2005; Colombia: 2003-2004; Costa Rica: 2008; Panama: 2008; Uruguay: 2005-2006). Data for OECD countries are from OECD (2009) except for Spain and Italy (Eurostat).
Notes | Indicators refer to the Manufacturing Industry. Weighted shares are reported only in the case of OECD countries and Brazil. 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).

Figure 10 | **Distribution of Innovation Expenditures by Firms**



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

insight into the way in which firms finance innovation activities and how they participate in national innovation systems. These two aspects are valuable in informing policy making and designing initiatives. Information from firms confirms that:

- Internal sources account for more than 70 percent of total financing of innovation, followed by commercial bank financing (between 10 and 20 percent). Public financing is a minor source of financing for firms in LAC. According to innovation surveys, less than 6 percent

of manufacturing firms in LAC receive public financing for innovation activities. Chile reports the highest share, with 8 percent of firms receiving government funding. These LAC figures are dwarfed by European averages.

- Links between firms, national science institutions, and universities are weak. Statistics from innovation surveys show that Latin American firms most often establish technological cooperation agreements with clients and suppliers. Available evidence suggests, however, that the goals of most cooperative activities are exchanging information and carrying out training activities (i.e., Anllo and Suarez, 2009).[9] Universities and institutes of technology are less important as partners for innovation activities.

Innovation and Employment

The relationship between innovation and employment is complex. Innovation can trigger different effects at different levels of aggregation (firm, sectoral, and country level), and across all these levels the relationship between these variables depends on many different transmission mechanisms, feedback loops, and institutional factors (Pianta, 2006). Recent evidence in developed countries at the firm level indicates that whether and how innovation creates new jobs depends first and foremost on the type of innovation (Harrison, et al., 2008) and the time frame considered. While the introduction of new processes is generally driven by labor cost considerations and tends to reduce the amount of labor used (the so-called displacement effect), the introduction of new products or services may replace or add to the list of existing products or services, with different effects on employment generation (known as the compensating effect).

Despite recent high economic growth, reducing poverty and inequality remains high on the policy agenda of many Latin American and Caribbean countries. Given the key role played by employment generation as a mechanism to reduce poverty and inequality, it is of particular interest to understand the effects of innovation on employment generation. Yet, evidence on the dynamic relationship between innovation activities and employment generation is lacking for Latin America. The idiosyncratic nature of innovation means that the findings highlighted above cannot be simply extrapolated to the region. Indeed, for Latin American firms, the acquisition of technological knowledge from abroad through contacts, trade, collaboration, and joint ventures with industrialized countries is very relevant (Katz, 1987). Technological change in developed countries might respond to different objectives, incentives, and factor endowments. In addition, the Latin American production structure is dominated by small and medium enterprises (SMEs), whose contributions to employment and innovation processes may differ significantly from those of larger firms. Although more likely to fail, when SMEs do survive, they normally show systematically higher employment-growth rates and can play an important role in job turnover (Doms, Dunne, and Roberts, 1995; Evans, 1987; and Hall, 1987). Additionally, innovation in SMEs is strongly dominated by informal searching routines and learning from available technologies, while in large firms innovation processes are more systematic and tend to be formalized in R&D labs (Baldwin, 1997).

To close this gap, the IDB is carrying out a multi-year project supporting studies in four Latin American countries (Argentina, Chile, Costa Rica, and Uruguay). The main focus of this research is the effects

[9] In Argentina, according to the innovation survey of 1998-2001, 84 percent of firms that cooperated with other actors in the national innovation systems for purposes of information and 58 percent for training purposes; only 21 percent engaged in cooperation for R&D. In Colombia (according to the pilot test of the Survey of Technological Development 2 for 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 percent, respectively.

of innovation on employment (both quantity and quality) at the firm level. Based on the methodology put forward by Harrison, Jamandreu, Mairesse, and Peters (2008), the analysis carried out so far shows that the introduction of new products is associated with employment growth at the firm level. Specifically, for manufacturing firms as a whole, the introduction of process innovations does not affect the rate of employment growth or specifically displace employment in the countries considered. Although the introduction of process innovations in both Chile and Uruguay implies an increase in productivity, the estimates are not significantly different from zero. At the same time, no evidence of displacement effects due to the introduction of product innovations has been observed. In fact, the observed compensation effects resulting from the introduction of new products imply employment growth even when the replacement of old products is taken into account. Similar overall results for product innovations—both in terms of direction and impact in employment growth—are found in the case of small manufacturing firms. Specifically, in all of the countries, the introduction of new products at a minimum compensates for displacement effects due to process innovations.

In summary, the evidence obtained so far supports the idea that the negative performance in the labor market tends to be related to the lack of product innovators rather than to the introduction of innovations (either process or product) as such. In this sense, and considering that innovation positively affects employment generation at the firm level, these results provide an additional rationale for policies aimed at the promotion of firm-level innovation.

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 financing and sufficient incentives for innovation. This situation clearly highlights the need for effective policy design and new approaches in 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 SMEs, and the creation of new firms. It should also strive for a better balance between basic and applied research (more oriented toward solving local problems and meeting the needs of industry). Further progress is also needed on the development and enforcement of appropriate regulatory frameworks for innovation.

Innovation surveys indicate that 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.

Innovation surveys point to the lack of financing as a major barrier to innovation investment in LAC firms (Navarro et al., 2010; Anllo and Suarez, 2009). This situation might reflect, in part, problems in the functioning of financial markets. Yet some of the failures in financial markets are due to the intangible nature of knowledge and the fact that it can be appropriated by others, as well as the inherent risk in innovation investments (see Box 2).

To tackle the problem of market failure through financing, several countries in the

region have been implementing support programs using subsidies or tax incentives. By sharing the risks, governments help reduce the uncertainty in innovation and therefore encourage 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 poor coordination among the components of national innovation systems, such as universities and commercial firms. Overall, the statistics reported earlier regarding the availability of human capital (Ph.D.s, researchers, and specialists) 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 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 imply diseconomies of scale for innovation projects, many of which require relatively large investments upfront and longer time horizons to realize a profit.

Some of the 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) health, safety, and environmental protection.

Box 2 | 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 costs of invention.[10] As knowledge shares some characteristics of public goods (non rival and non-excludable good, and indivisibility), firms may be unable to exclude others from its use and appropriation. 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.[11]

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 (or its economic impact).[12] Therefore, it is difficult to negotiate a loan for insecure assets and to enter into contracts based on knowledge assets as collaterals or warranties.

Difficulties in accessing financing arise then because of 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.[13] 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).

[10] 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).
[11] The IPR system is not without cost and, as with other policies, its effectiveness depends more broadly on institutional development and the 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). Close interaction and joint work with competition and antitrust policies is needed to monitor abuses of the systems by companies seeking to influence competition.
[12] This problem is particularly accentuated in basic research, which is one of the reasons that more support (in the form of subsidies or tax incentives) should be provided to this type of project compared to applied research or development.
[13] 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 (collateral, insurance, and as means of securitization. See Yanagisawa and Guellec, 2009).

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 these 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 paces and frequently in accordance with the prevailing economic agendas of the administrations in power.

However, there are some common patterns in terms of the implementation 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, resulting in an underdeveloped culture of networking and a 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) supply-oriented policies, ii) demand-oriented policies, and iii) strategically 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, and the last group centers on the development of strategic policy programs and the articulation of 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, groups 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 complement 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

Supply-side policy instruments focus basically on the generation of new scientific knowledge, both basic and applied, and the formation of human capital and infrastructure in science and technology (S&T). These policies include developing university and public research centers with the right infrastructure in scientific disciplines and 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 LAC countries have supply-oriented policies on their agendas today. In fact, this policy approach was the main component of public policy for innovation from the 1950s until the mid-1980s. The traditional instruments for promoting scientific research include funds for science and infrastructure, subsidies, research grants, and scholarships. For training of human capital in S&T, policy instruments include undergraduate, graduate, and post-graduate scholarships, scholarships for doctoral and post-doctoral studies abroad, and educational programs in technical areas, among others.

In recent years, policy in this area has evolved substantially. More attention is being paid to the development of domestic graduate and research programs that will be able to accommodate new Ph.D.s 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 research career objectives and monetary incentives for research by professors). The creation of centers of excellence is also attracting interest. Centers of excellence seek to position the country or the region's research institutions among the top ranking research institutions worldwide. Their creation frequently involves a combination of resources, subsidies, and grants from both federal and local budgets. Two examples of this are the Programa Iniciativa Científica Milenio (ICM) in Chile and the Centro de Excelencia en Genómica in Colombia.

However, policy mechanisms for integrating with 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 a useful first step toward a better matching to industry needs. This does not mean completely excluding basic research, but rather striving to balance discovery-driven research and more demand-driven research. Promoting the mobility of researchers from public institutions to the private sector through specific public-private incentive programs is another important step in balancing the employment of human capital across the innovation system. These policy strategies include the 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) and job creation programs for doctoral and master's program graduates (i.e., scholarship grantees).

Some countries in LAC continue to confine innovation policy to the supply of scientific research and infrastructure, leaving innovation capacity in the business sector unattended. The prevalence of a supply-side approach over several decades has left a deep legacy in most LAC countries: that 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 strengthening innovation capacity 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 industry. 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 capacity in firms. The chief policy targets are the generation of new, high value-added products and services, which leads to competitiveness and superior economic performance.

The set of policy instruments designed to stimulate R&D investment in firms includes technology and innovation funds (loans and grants to firms, associations of firms, consortia and firms' research networks); competitiveness funds (credit and grants frequently associated with increasing productivity, quality standards, and exports); fiscal incentives (R&D tax deductions);[14] venture capital (initiated mostly by public capital); and research consortia (targeting industry co-operation). Technology development funds (TDF) usually provide non-reimbursable loans to technological innovation projects involving SMEs. Some of these policy programs are geared to the needs of specific industries, while others are horizontal instruments devoted to addressing needs in specific areas of private-sector technological development.

Several countries in the region are just beginning to use these policy tools. Some instruments, such as technology funds, have reached an important level of maturity in 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 TDFs in six countries found that, in general, the economic results are positive as evidenced by the estimated rates of return and 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 investment (Lopez, 2009).

Supporting 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, 3 percent in Panama and Costa Rica, 5 percent in Argentina and Colombia, 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) and Austria (24 percent).

Lessons from programs in STI in different countries worldwide suggest that it is important to achieve a balance between supply-side policies and demand-side policies. In particular, care should be taken to balance the need to establish a critical mass of scientific and engineering capacity with the need to incentivize private R&D (demand). In many LAC countries, it is unlikely that the private sector will take the lead in R&D given current levels of human capital available for STI. Policies should target these two dimensions, in some cases jointly (i.e., high-level researchers and technology specialists for industries).

3) Strategy-oriented and Articulation Policies

Implementing strategy-oriented and articulation-oriented innovation policies involves a more comprehensive approach, which aims to address coordination failures among the diverse actors in the innovation system and reinforce innovation capacity in sectors deemed strategic for the country's competitiveness and social progress. Articulation policies are instruments that help to address other market failures, through the internalization of spillovers by promoting cooperation, the search for innovation complementarities, and risk sharing among firms and institutions.

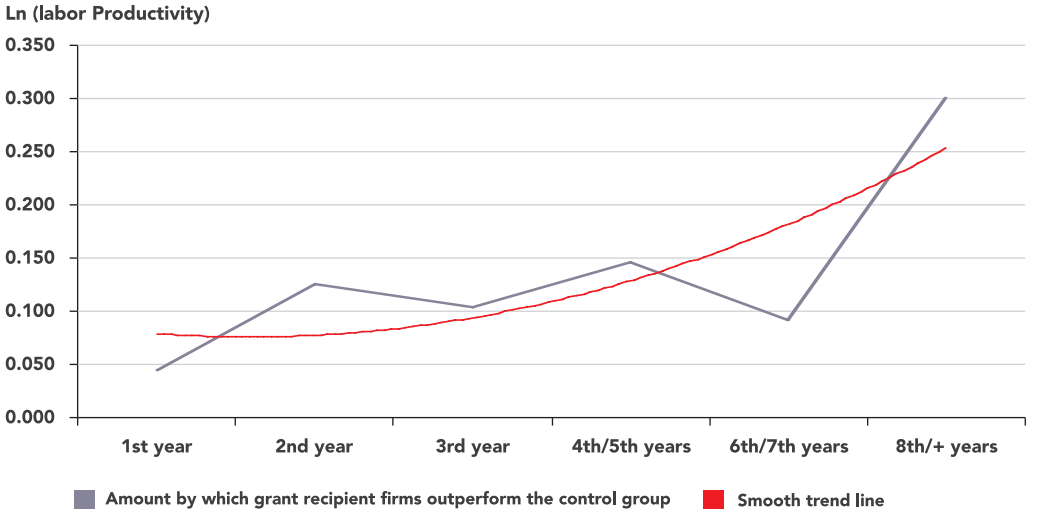
[14] Tax incentives typically include: 1) reduction in the corporate income tax rate, 2) reduction in the value-added tax rate; 3) accelerated depreciation of capital goods and equipment acquired in the context of an innovation project; and 4) fiscal credits for expenses and additional investments in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

Box 3 | Assessing the Long-run Effects of Technology Development Funds

Technology development funds (TDFs) are a key component of the set of policy instruments that various LAC governments have implemented in the region to support innovation. TDFs are complex instruments that aim to correct market failures that harm innovation, such as disincentives generated by the lack of appropiability of innovation outcomes, lack of external funding due to information asymmetries in the financial markets, and lack of complementary access due to the poor density of local innovation systems. Despite their popularity, further research is still needed to understand the long-run effects of TDFs. Past IDB evaluations have consistently shown that TDFs are effective at the level of R&D input additionality (Hall and Maffioli, 2008). In particular, these studies found that public funding does not crowd out private investment and in many cases has a positive effect on the firm-level intensity of R&D. However, evidence regarding the impact of TDFs on innovative outputs and firm performance is inconclusive.

To close this gap, the Bank carried out a study on the long-run dynamic effects of a matching-grant program managed by the Colombian innovation agency COLCIENCIAS. Beneficiaries of the program were almost entirely small and medium enterprises. The study was designed to take advantage of panel data which is sufficient to detect the long-run effects of the program (Crespi, Maffioli, and Melendez, forthcoming 2011). The study shows that COLCIENCIAS' funding not only had a positive impact on firms' investment in innovation, but also had a significant impact on their performance. It also provides evidence that these effects persist and, in some cases, increase over time. Of particular interest are the effects on productivity. Between 1995 and 2007, COLCIENCIAS funding had an average impact on the introduction of new products and labor productivity of 12 percent and 15 percent respectively, with these effects becoming more significant between three to five years after the firms received the funding (see Figure 11). These findings imply not only that beneficiary firms become more efficient, but that they grow more and gain a larger market share than the control group. The result is that economic resources are being reallocated towards more productive firms, hence impacting productivity in the aggregate.

Figure 11 | **The Impact of COLCIENCIAS Matching Grants on Firm Productivity in SMEs (percent differences compared to the control group)**



Sources | Crespi, Maffioli, and Melendez, 2011 forthcoming.

The importance of these results is twofold: first they confirm that TDFs are effective not only in promoting R&D investments, but also in boosting firm performance in the long run. Secondly they show that longer-term impact evaluations of such projects enable the detection of impacts on some of the most relevant variables of interest.

To obtain these results, the COLCIENCIAS evaluation relied on a unique data set. The study matched the administrative records from COLCIENCIAS with the Annual Manufacturing Survey and the Colombian National Innovation Survey, both collected and managed by the Colombian Statistical Office DANE. In this way, it was possible to estimate the effect of public funding on firm-level indictors over an eight-year period.

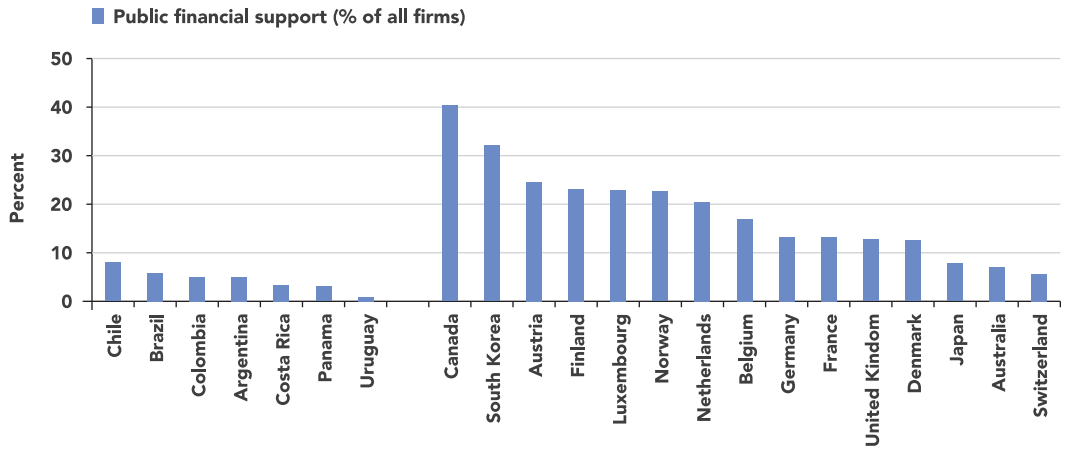
This new policy orientation began in the mid-1990s in the LAC region. It basically seeks to shift the emphasis of innovation policies away from a singular orientation rooted in either supply or demand, toward a more strategic, integrated approach. The idea behind this approach is for countries to gradually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

Within this approach, the goal of strategically oriented policies is to enable the country to develop STI capabilities in industries or technology areas that are deemed to have a significant crosscutting economic 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 certain economic sectors in accordance with their relevance for national competitiveness and social importance (i.e., agricultural industries). Hence, vertical approaches (addressing specific industries and their value chain) co-exist with more traditional horizontal ones (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 (Box 4), 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, and promotion of international innovation networks (linkages to global research networks and between national researchers and firms abroad).

Programs organized around the notion of clusters are focusing on technology and innovation and are increasingly combined with efforts to strengthen regional and municipal innovation systems. In addition, explicit mechanisms of intersectoral coordination in innovation policy, such as industry roundtables and innovation workshops on shared research agendas, have been introduced as a deliberate attempt to improve coordination and encourage pooling of resources and sharing of priorities among the key actors of the innovation

Figure 12 | **Percent of Firms that Received Public Support to Finance Innovation Activities**



Sources | Innovation Surveys (Argentina: 1998-2001; Brazil: 2005; Chile: 2004- 2005; Colombia: 2003-2004; Costa Rica: 2008; Panama: 2008; Uruguay: 2005-2006). Data for OECD countries are from OECD (2009).
Notes | Indicators refer to the manufacturing industry. Indicators are weighted for OECD countries; data for LAC countries (except Brazil) is provided by researchers and is unweighted.

Box 4 | 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 meet the needs of the productive sector, envision solutions for social problems, and improve the performance of skilled workers. The program co-finances projects in these three areas, regardless of sector. Public and private entities in Uruguay can apply for financing and must be undertaking R&D activities and must demonstrate their potential to provide S&T services.

- **Mexico: Sabbaticals in industry by academic researchers**

CONACYT (National Council of Science and Technology) sponsors sabbaticals for researchers and post-doctoral candidates in industry, specifically in activities related to R&D and innovation. The objective is to increase the competitiveness of companies by strengthening technological and innovation processes. It also aims to strengthen the skills of industrial workers, generate R&D projects, and increase interest on the part of academia in helping firms solve problems using technology.

- **Peru: Centers for Technological Innovation (CITES)**

CITEs are technology partners for companies aimed at increasing their capacity to innovate and to increase their competitiveness and productivity. Each CITE provides training, technical assistance, information, assistance with productive processes and quality control, computer assisted design, and environmental technologies. Each CITE is a meeting point for public institutions, academia, and the private sector. Its aim is to link the elements of the national innovation system in each production chain. The goals are to facilitate and promote technological change, quality, innovation, and productivity in companies, especially SMEs, in order to make them more competitive 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/

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, and Rio de Janeiro, Brazil; computer science and informatics in Campinas, Sao Leopoldo, Brazil, and Monterrey, Mexico.

Another area where articulation policies are needed is in 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 technology start-ups; and the financing or co-financing of intellectual property protection, including financial support for application and renewal fees.

Technology transfer institutions are particularly important in helping firms that are lagging behind technologically to catch up. This is especially true of SMEs, which are frequently disadvantaged relative to larger firms in terms of access to technology and human resources in S&T. Technology transfer centers and technical institutions provide technology extension services that can help strengthen capacity in firms. They providing 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 and with other industries).

The rise of policy programs targeting specific technologies and/or industrial sectors is a response to the view that world-class economic competencies are a product of knowledge-intensive efforts

in activities that promise high impact. Some of these sectors have industries or technologies in which the country's competencies are still embryonic but the sector is deemed strategic for future economic performance. Some examples are semiconductors and nanotechnology. FONSOFT software in Argentina and CT-BIPOTEC in Brazil are examples of such programs. Some policy programs target sectors in which countries have a competitive advantage but need to improve their performance through knowledge and innovation. Among the instruments promoted in this approach are sectoral and technology funds (e.g., INCAGRO-FTA in Peru (agriculture); FIP (agriculture); and FIA (fishing) in Chile) and other programs targeting crosscutting areas.

Sectoral funds[15] are being used in widely in Brazil and Mexico, and are just beginning in Argentina and Chile. In 2008-2009, Brazil had 14 sectoral funds. These are frequently trusts or fiduciary funds used to allocate and coordinate resources for R&D in sectors that are deemed strategic for economic growth and competitiveness. Some examples are the fishing industry in Chile, and the agriculture, water, and health sectors in Argentina.[16]

Programs to support crosscutting areas include the creation of funds for sustaining technology development in technologies or sectors that have an impact throughout the economy and society. Some examples are information and communication technologies and environmentally friendly technologies. Crosscutting sectors include transportation and energy. Some programs established to support crosscutting sectors include CT-AEREO and CT-ENERG in Brazil and the Sectoral Fund for Technology Development in Energy by CFE-CONACYT in Mexico.[17]

Priority Area Programs are designed to support S&T activities for social development. Activities include the mobilization of human and financial resources for R&D, which is frequently done by specialized national research centers, and the dissemination of cost-effective technologies that have broad application in society. Some 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 centers addressing industry needs are also expanding in the region. In some countries, these centers were created as far back as the 1930s. INTA in Argentina and CENIS in Colombia are two examples. In Colombia, the Colombian Corporation for Agriculture and Farming Research (CORPOICA) seeks to generate and transfer scientific knowledge and technological solutions to the agriculture sector. Its aim is to become the leader in research and innovation and to contribute to the articulation of the national innovation system and the integration of local teams with international networks in S&T.

It is too soon to be able to see concrete results from the use of sectoral instruments. However, some interesting recent examples provide grounds for optimism. Successful sectoral policy initiatives are found in Brazil and Argentina in the area of agricultural exports. These efforts have emphasized collaborative

[15] There is still no standard definition of sectoral funds. Sectoral funds or initiatives are found in the public or private sector. They may support individual economic sectors or industries such as fishing or agriculture or major public utilities such as water, transportation, or energy. In some countries, sectoral initiatives support technology sectors such as biotechnology or nanotechnology.
[16] The funds support technological development and sectoral innovation by addressing the requirements for strengthening research capabilities: the transfer of scientific knowledge to industry, capacity building, upgrading of quality standards, etc.
[17] Brazil has two important horizontal funds: VERDE AMARELO for strengthening R&D linkage between universities and firms, and FUNTTEL, for the development of Telecommunications.

Box 5 | Examples of Sectoral Funds in Latin American Countries[18]

- **Argentina**

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

- **Chile**

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

Fund for Fishing Research (FIP): This fund finances 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 Innovation and Competitiveness in Peruvian Agriculture Program (INCAGRO): this fund promotes basic research and technology extension services for different projects along the value chain. INCAGRO has successfully been promoting a public-private network of information in science and technology related to agriculture (AGRORED PERU) as fundamental to the 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. It also provides adaptive research services, by solving technical problems that limit productivity and competitiveness through the adoption and adjustment of existing technologies. INCAGRO also channels assistance to improve the 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/

processes between public research institutions, technology transfer, extension services, and industry. A similar synergy is developing in the emerging agricultural machinery industry in Argentina (Lengyel, 2009).

Institutional Development and Governance of Innovation Policies

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

In general, with respect to human capital development for innovation, all countries have at least some instruments. However, countries have fewer instruments devoted to strategic and selective policies, even those with the most highly developed innovation policy institutions.

[18] Other countries such as Mexico and Brazil have extensive experience with sectoral funds. Please see Ventura (2009) a report conducted by an IDB consultant analyzing the use of sectoral funds to promote R&D and innovation in Mexico, Brazil and Chile.

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 for national graduate programs 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/
Notes | ARG = Argentina, BRA = Brazil, CHL = Chile, COL = Colombia, CRI = Costa Rica, DOM = the Dominican Republic, GTM = Guatemala, MEX = Mexico, PAN = Panama, PER = Peru, PRY = Paraguay, SLV = El Salvador, and URY = Uruguay.

Experience has shown that the emergence of a new approach to innovation policy has always been accompanied by institutional development and new governance mechanisms. Implementing a combination of policy instruments presupposes a certain level of institutional development to manage, monitor, and evaluate them. The heterogeneity in policy actions and availability of policy instruments in Latin American and Caribbean countries (Figure 13) reflects the divergence in institutional development across countries.

When LAC countries began implementing S&T policy, most policy actions were centralized in national councils of science and technology and similar agencies. The supply-oriented policy approach, which focused primarily on the development of physical and human capital for scientific research, was—and remains, in some countries—under the management of these planning and implementation agencies. With the introduction of innovation funds in the mid-1980s, these institutions had to broaden their mandates or create new agencies specialized in the management of competitive funds for innovation and research. This involves, inter alia, issuing calls for research proposals, processing and evaluating projects, and selecting and managing committees of experts to evaluate the proposals.

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 coordination has prompted some countries to create new entities for the promotion and management of innovation policies. Examples include the creation of the Ministry of Science, Technology, and Innovation in some countries, the elevation of national councils to the level of ministries in others, the emergence of innovation and competitiveness councils (akin to what the OECD has labeled the "whole government approach" to innovation), and a reorientation of S&T councils with a greater emphasis on coordination within and among sectors. Under this approach, discussion, partnership, and coordination between government and industry are key elements in the design and implementation of policies. Policies are arrived at through political consensus and coordination, enabling and ensuring effective implementation and consistency over time.

Some LAC countries, such as Brazil, Chile, Colombia, and Argentina, are evolving toward this institutional approach, which differs substantially from more traditional National Councils of S&T (CONICYTs). The new institutional modalities are characterized by: i) shared responsibility between one or more executive agencies 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. Such cabinets exist today in Chile and Uruguay. These initiatives are an attempt among key stakeholders to partner with each other and to strengthen the role of innovation policy in the overall national development strategy.

The evolution toward more coordinated and multifaceted policies that combine horizontally and vertically focused policy programs has been gradual. In many countries it is still a work in progress. In some countries, this renovation has led to the advent of new practices in research planning and competition for policy support, notably in the area of scientific research grant competitions.[19]

There is no one-size-fits-all model of governance with respect to innovation policy. The creation of new agencies for innovation explicitly targeting the business sector and the creation of national councils assisting policy design attract interest and can play a positive role in policy design and implementation. However, these are just some of the possible institutional mechanisms for addressing specific national priorities or weaknesses in innovation policy and governance. The need to rethink institutional governance for innovation policy is a country-specific task. Institutional solutions depend on the peculiarities of each country's institutional framework.

Innovation Policy Challenges and the Need for Institutional Capacity

In the end, the arsenal of policy tools available to LAC countries promoting innovation is not very different from the one available to OECD countries. However, the similarities conceal some significant differences. While advanced economies have a well-established institutional framework that is routinely financed and has considerable built-in management capacity, such a framework is still in the early stages of development in most LAC countries. A sudden economic or political crisis, or even the routine turnover of political appointees following an election, can leave innovation institutions weakened

[19] 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 proposals, require researchers and scientists to develop new competencies as well as conceiving research projects in new ways, often including accommodating industry participation.

and scrambling to retain or recruit 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 take for granted.[20] Countries in LAC face important challenges in terms of policy making and institutional maturity. Among the pending challenges are:

- The need to sustain policies over the long term. 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 bring about continuous policy action in these domains.

- The need to strengthen institutional capacity to formulate, monitor, and evaluate innovation policies. Monitoring and evaluation are key elements in the policy-making process. They serve to inform future policies and provide input for mid-course corrections of objectives and targets. Evaluation and oversight are weak in most LAC countries and should become a central part of the new culture of innovation policy practice.

- The need to develop information infrastructure to monitor STI-financed projects, and build it into planning and budgets. Recent programs in Argentina and Uruguay emphasize institutional development and data infrastructure for S&T policy making (e.g., plans for the creation of an 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, as well as policy delivery and monitoring (see Box 6).

[20] 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.

Box 6 | Institutional Development Challenges

In a recent survey of institutions responsible for the implementation of innovation policy, Ventura (2010) found the following challenges:

- Modernization of information systems. Although most institutions have introduced technologies to improve the management and control of information, the use of information systems is still limited. 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 surveyed report only partial development in this area. The limited use of information systems affects the ability to improve access and delivery of benefits, facilitate control and management, and strengthen conditions for transparency (including improving consultation by beneficiaries).

- Planning and implementation. Improvements in planning and implementation have been made, notably in Uruguay, Chile, and Brazil. However, in many countries these activities are still weak or absent. By 2010, Peru, Panama, and Guatemala had not set STI expenditure targets relative to GDP.

- The productive process: promotion, processing, delivery, and supervision. The degree of formalization of procedures varies from country to country. Procedures are most efficient with respect to the receipt of applications and the delivery of benefits. Two areas that represent an important challenge for institutions are attracting new beneficiaries and supervision—the two ends of the business cycle. The level of development of these two activities varies dramatically across LAC countries. In some countries they are non-existent; more advanced economies have documented processes with modules managed by information systems.

- Attracting new beneficiaries will require marketing strategies, including proactive approaches to identify customers who could take advantage of the policy instruments. Coordinating with industry associations is one element of such a strategy. Departments in charge of serving potential beneficiaries and the public should be able to analyze business directories, economic censuses, surveys, and other statistical information to identify potential beneficiaries and develop promotional strategies and events. Improving supervision requires closer interaction with beneficiaries to acquire firsthand knowledge about what works and build consensus around good practices.

- Monitoring, evaluation, and transparency. Five out of eight institutions reported that they regularly evaluate programs and disseminate the results through workshops and publications. Overall, published data about benefits, beneficiaries, and job vacancies is not widely distributed. Dissemination of information on policy effectiveness requires the political will to be accountable and transparent.

Chapter II

THE IMPERATIVE OF INNOVATION
CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

2nd Edition · 2011

II. Information and Communications Technology for Productivity and Social Development

The Persistent Digital Divide[21]

A key driving force behind the creation of a knowledge economy is the exponential growth in the volume and speed of information generated by the expansion of information and communications technologies (ICTs). Indeed, given that ICTs substantially lower the cost of information storage and transmission, their diffusion throughout the economy reduces the uncertainty and transaction costs associated with economic interactions. ICTs shorten the 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 more outputs from the same set of inputs; in other words, ICTs have become a trigger for higher productivity levels (Chen and Dalhman, 2005).

ICTs increase the organizational capacity of firms to codify knowledge that otherwise would remain tacit, accelerating learning and reducing problems related to "organizational forgetting" (Foray, 2007). 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 facilitates a higher degree of customization, opening up 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, 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. 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 (due to income inequality within countries).

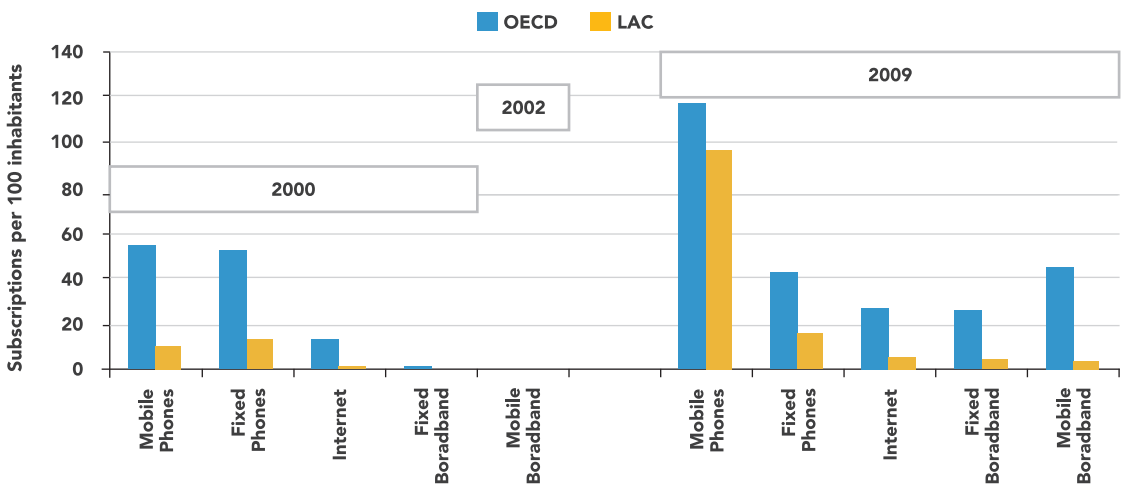
[21]The concept of "digital divide" has evolved over time. Initially, it referred to differences among countries, regions, or families only in access to ICTs, normally measured in terms of fixed telephone, mobile telephone, Internet, broadband, and computer hardware. However, over time the concept has broadened to include patterns of use, such as imbalances in the capabilities and skills needed to actively engage in the knowledge economy. The trends discussed in this section mainly focus on the access dimension of the digital divide.

Table 1 | **ICT Subscriptions per 100 Inhabitants, OECD and LAC Countries, 2000 (or 2002) and 2009**

Subscriptions per 100 Inhabitants				
ICT	**OECD 2000**	**OECD 2009**	**LAC 2000**	**LAC 2009**
Mobile	54.7	116.9	9.9	96.5
Fixed Phones	52.4	42.5	13.1	15.5
Internet	13.4	26.9	1.1	5.5
Fixed Broadband	1.4	25.6	0.03	4.5
ICT	**OECD 2002**	**OECD 2009**	**LAC 2002**	**LAC 2009**
Mobile Broadband	0.02	45.3	0.0	3.4

Source | ITU

Figure 14 | **ICT Subscriptions per 100 Inhabitants, OECD and LAC Countries, 2000 (or 2002) and 2009**



Source | ITU
Notes | 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.[22]

Internationally, the digital divide between the OECD and LAC countries persists (Table 1 and Figure 14). Although ICT penetration increased in the Latin American region between 2000 and 2009, 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:

[22]Mexico and Chile are included in LAC and not in OECD. The Slovak Republic is included in 2000 data; it joined OECD in December of 2000. Fixed Phones: Main (fixed) telephone lines per 100 inhabitants. Mobile Phones: Mobile cellular subscriptions per 100 inhabitants. Internet: Internet subscriptions per 100 inhabitants. Fixed broadband: Fixed broadband subscriptions per 100 inhabitants. Mobile Broadband: Mobile cellular subscriptions with access to data communication at broadband speed per 100 inhabitants. For mobile broadband subscriptions, included in 2009 averages are data from 2008 for the following countries: Chile, El Salvador, Haiti, Honduras, and Panama in the LAC average and Canada, Czech Republic, France, and Norway in the OECD average.

• In mobile and fixed telephony, the gaps are decreasing. OECD countries are experiencing an absolute decline in the number of fixed telephone lines per 100 inhabitants (from 52.4 in 2000 to 42.5 in 2009), whereas LAC countries have increased the number of fixed telephone lines (from 13.1 to 15.5 from 2000 to 2009) 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 with mobile phones. In fact, the adoption of mobile telephony has increased sharply in both the OECD and the LAC regions. However, there is still a substantial gap in both telephone technologies with respect to the OECD countries.[23]

• The LAC region has rapidly adopted mobile telephony (subscriptions per 100 inhabitants grew from 9.9 in 2000 to 96.5 in 2009). OECD mobile phone adoption over the same period was also substantial, increasing from 54.7 to 116.9 per 100 inhabitants. While in OECD countries mobile penetration more than doubled from 2000 to 2009, mobile penetration in 2009 in LAC is almost ten times what it was in 2000. The impressive increase in mobile telephony in LAC opens up opportunities for leveraging this technology to deliver business and social services.

• With respect to Internet and broadband subscription rates, the digital gap is definitely increasing. Although in the LAC region the number of Internet subscribers has increased from 1.1 to 5.5 per 100 inhabitants between 2000 and 2009, OECD adoption rates grew from 13.4 to 26.9. Thus, the absolute gap between the two regions grew from 12.3 to 21.4 subscribers. The digital gap is growing even faster in the case of broadband due to the more rapid diffusion of this technology in OECD countries.

• In terms of mobile broadband subscriptions (defined as mobile cellular subscriptions with access to data at broadband speed per 100 inhabitants), levels of mobile broadband penetration are within striking distance of those of fixed broadband. If 2008 data from some countries were not factored into the average, mobile broadband penetration levels in LAC would reach 4.4 subscriptions per 100 inhabitants rather than the 3.4 reported in Table 1. This good news is mitigated by the fact that most LAC countries for which data are not reported in 2009 are likely to have lower levels of penetration (El Salvador, Haiti, Honduras, and Panama). Furthermore, mobile broadband penetration levels in OECD countries are nearly double those of fixed broadband, and the gap between the regions remains very large—41.9 subscriptions per 100 inhabitants.[24]

A 2011 IDB study empirically addressed the causes of the region's gap in adoption and use of ICTs with respect to OECD countries. It analyzed the diffusion of ICTs in a country as a function of (i) per capita income, (ii) the stock of human capital, (iii) population density, (iv) regulatory quality, and (v) degree of trade openness.

The results clearly show that most of these factors are relevant determinants of country-wide technology diffusion. Not

[23] As mobile phone technology is quickly evolving (e.g., smart-phone technology), the concept of a mobile phone itself is changing from a simple instrument of voice communication to something far more sophisticated. Although overall access gaps between LAC and OECD countries 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.

[24] Similar to mobile phone technologies, however, available international indicators do not control for differences in the quality of the equipment. Thus, the difference between LAC and OECD with respect to information storage, processing capacities, speed, and applications may not be fully reflected in the raw numbers.

surprisingly, for all of the technologies, the factor that contributes most to the gap is per capita income. The lower contribution of income to the mobile phone divide can be explained by the relatively lower cost of access to that technology. Additionally, human capital and differences in regulatory quality contribute significantly to technology gaps, while population density and trade openness are less relevant.

In summary, the global digital divide between LAC and the OECD is mainly explained by differences in structural variables, such as income and education. This may imply that digital convergence is not expected to occur within a reasonable time frame (perhaps with the exception of mobile telephony). However, this does not mean that nothing can be done to mitigate the digital divide in the short run. For example, the importance of the quality of regulation as an explanatory factor for adoption rates suggests that significant short-run gains can be achieved by applying the correct set of regulatory reforms, especially in the case of mobile telephony and broadband. (For a simulation of scenarios assuming different rates of technology diffusion, see IDB, 2010b.)

From Subscribers to Users

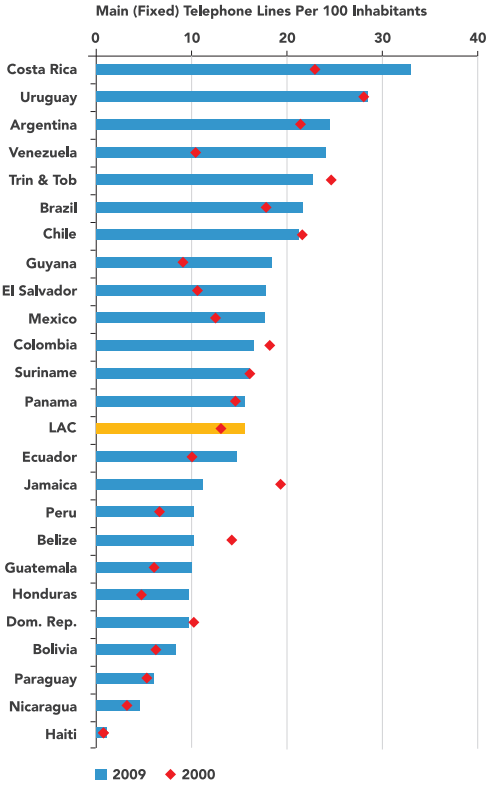
When analyzing the Internet divide, it is important to differentiate between subscribers and actual users. On average, in LAC countries there are 21.1 fewer broadband subscriptions per 100 inhabitants than in OECD countries; however when measured in terms of users, the digital divide in Internet decreases between the two regions, at least in the last three years. This different pattern between subscriptions and users is mostly explained by the higher relative importance of collective use points (e.g., Internet cafés, telecenters, schools, and libraries) in this region compared to OECD countries (Peres and Hilbert, 2009).

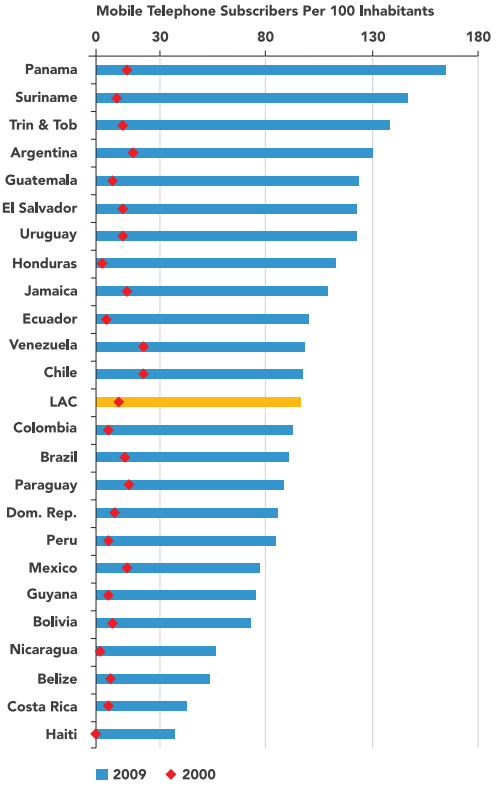
Regarding the second digital divide, statistics also reveal heterogeneity within the region (Figure 15). In Internet and broadband subscriptions, Argentina, Chile, Uruguay, and Mexico are regional leaders, whereas low-income countries such as Honduras, Nicaragua, and Guatemala rank among the countries with the lowest penetration. Costa Rica, Uruguay, and Argentina are the regional leaders with respect to fixed telephone lines per 100 inhabitants. Paraguay, 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, while Bolivia, Belize, and Haiti are at the bottom.

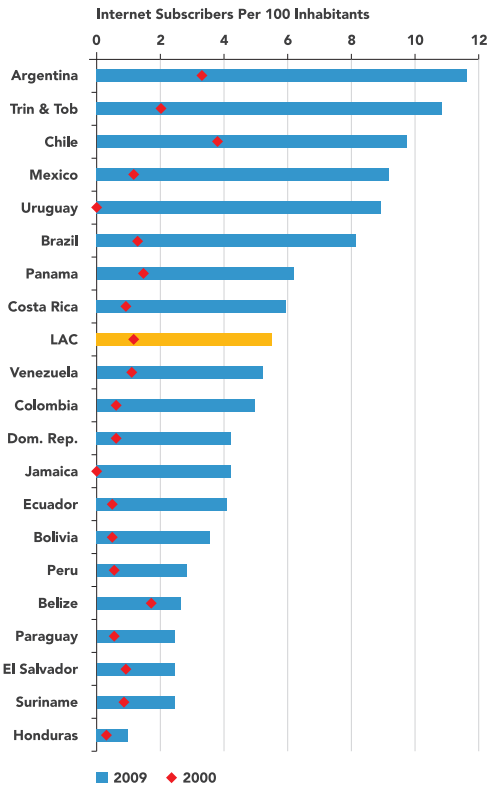
Interestingly, mobile telephony is the only ICT where Central American countries appear to have caught up with the regional average. This suggests that barriers such as lack of infrastructure, cost, and skills are less binding for low-income countries in the case of mobile phone technologies. As long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

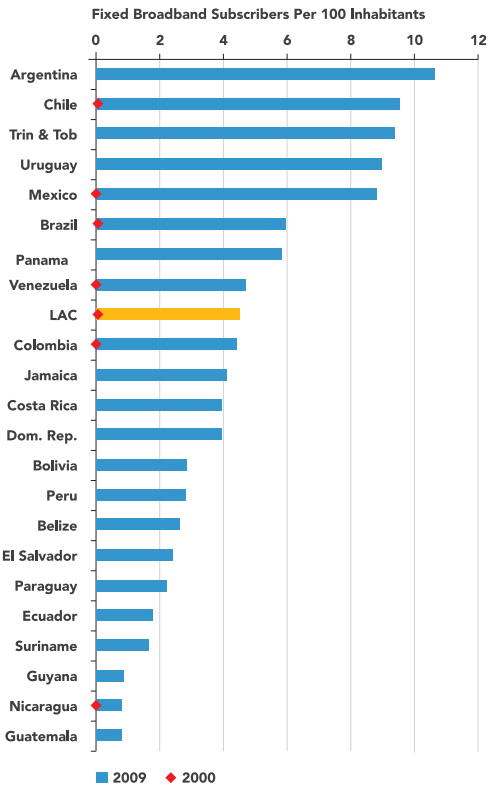
There is disparity across LAC countries in the penetration levels of mobile broadband. Mobile broadband penetration is gaining ground in the countries on the left-hand side of the figure, with up to 30 percent of the population in Trinidad and Tobago subscribing to mobile broadband, followed by Venezuela, with over 10 subscriptions per 100 inhabitants, and a handful of countries, such as Argentina, Mexico, Brazil, Uruguay, hovering around 5 percent. Many of the countries on the right-hand side of the figure, including

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









Source | ITU statistics.

Suriname, Bolivia, Colombia, El Salvador, Haiti, Honduras and Panama, report negligible levels of penetration or none at all.

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. 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.

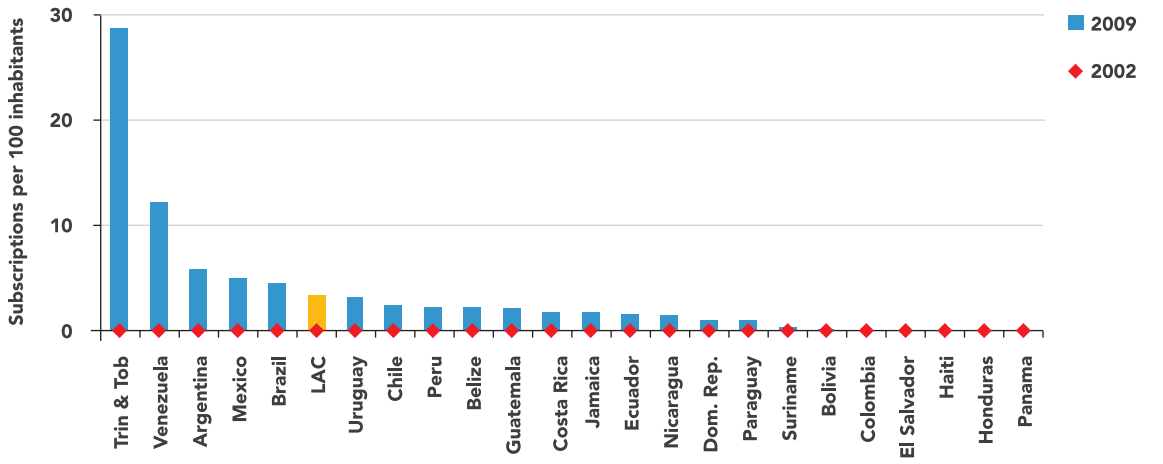
Figure 17 compares the percentage of households with access to Internet at home by income level. The data for LAC countries are presented in five income quintiles. For all countries, the highest Internet penetration rates are in the fifth income quintile (the richest income bracket). As we move to lower quintiles, household income decreases, and along with it the proportion of households with access to the Internet sharply decreases. European countries follow a similar pattern. 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, Uruguay, Costa Rica, Chile 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 are available. Yet, the disparity can be deceptively greater in countries that have weak Internet penetration overall.

For example, Figure 18 shows that in Peru households in the highest income

Figure 16 | **Mobile Cellular Subscriptions with Access to Data Communication at Broadband Speed per 100 Inhabitants, 2000 and Latest Available**



Source | ITU
Notes | Latest available data for Chile, El Salvador, Haiti, Honduras, and Panama were from 2008 and are included in the 2009 LAC average.

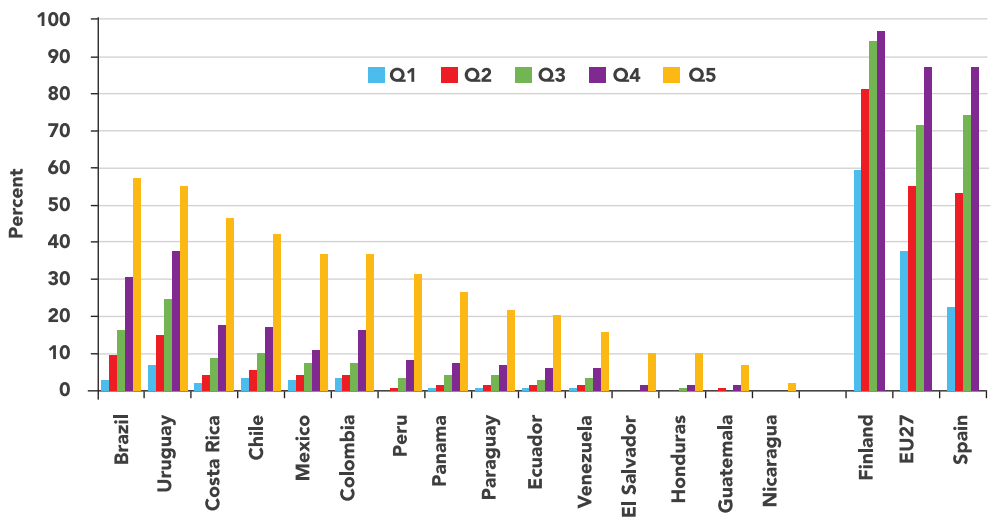
bracket report about 100 times more Internet access than households in the lowest income bracket. By comparison, households in the highest quartile in EU27 have 2.3 times the access to Internet when compared with households in the lowest income quartile. Many of the countries do not report data for an 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), inequality in Internet access (Figure 18) has decreased over time.

In addition to its impact on individuals and households, ICT has drastically changed how modern business is conducted. In the information era, ICTs benefit enterprises in two main ways: they increase productivity by increasing the efficiency of internal processes and they broaden market reach both domestically and internationally.

However, ICT adoption in Latin American enterprises is still insufficient, especially in SMEs. Firms face several constraints when adopting ICT technologies. First, they incur high fixed costs associated with purchasing and maintaining hardware and software and adapting it to production processes, disrupting normal business processes. 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, services provided online are still limited and their regulation is embryonic, consequently reducing the attractiveness of ICT adoption.[25]

In summary, household information indicates that a large digital divide remains regarding the adoption of ICTs in LAC; even more worrisome is data suggesting

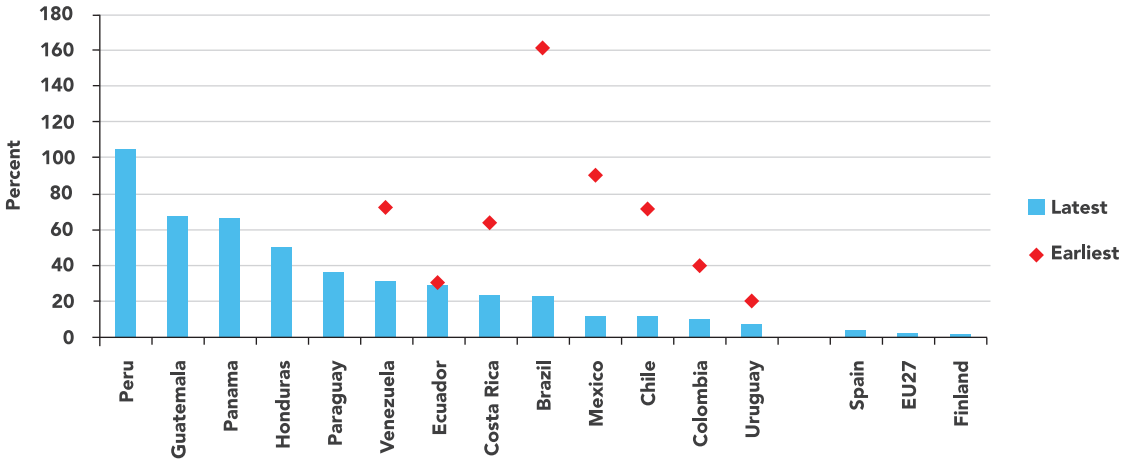
Figure 17 | **Percent of Households with Access to the Internet in the Home by Income Quintile (1-5) for LAC or Quartile (1-4) for Comparison Countries, 2009 (or Latest Available)**



Source | OSILAC Database (secondary source; national household surveys are the primary source) and Eurostat.
Notes | Latest available data for Brazil, Colombia, El Salvador and Paraguay are 2008, Bolivia, Honduras, Mexico, Panama, and Venezuela are 2007, and for Chile, Guatemala, and Nicaragua are 2006.

[25]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 on innovation through industrial surveys, and some are developing ICT surveys.

Figure 18 | **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, 2009 (or Latest Available)**



Source | OSILAC Database (secondary source; national household surveys are the primary source) and Eurostat.
Notes | For the comparison over time, data for the earliest year are only reported when a minimum of four years have elapsed. Latest available data for Brazil, Colombia, El Salvador, and Paraguay are 2008, Bolivia, Honduras, Mexico, Panama, and Venezuela are 2007, and for Chile, Guatemala, and Nicaragua are 2006. Earliest available data for Chile, Costa Rica, El Salvador, Guatemala, and Paraguay are 2000, for Brazil, Mexico, and Uruguay are 2001, and for Colombia, Ecuador, and Venezuela are 2003.

that, with the exception of telephony, the gap is 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 countries at levels not very different from the least developed countries of the OECD and a large set of countries dramatically lagging behind except in mobile phone technologies. The other occurs within countries. Although inequality within countries is decreasing, it is still higher than in Europe. The picture is not as bleak when comparing ICT use by businesses in the LAC region to the OECD region. Although the evidence is somewhat weaker in terms of the quality of the data, available data suggests a pattern of adoption and use in the region that is not dramatically different from what we observe in more developed countries, although adoption in LAC has come later (see Box 7).

Latin American and Caribbean governments have progressively recognized the opportunities opened up 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.

Key Challenges in ICT Policy

The challenge for Latin American and Caribbean countries is not only how to close the digital divide but also how to take advantage of ICT to implement national development strategies. The utility of ICTs depends on their efficient use, and that means incorporating them adequately into innovation networks, production systems, and society as a whole. As Peres and Hilbert (2009) found, 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. Absorptive capacity, specifically ICT skills, is indispensable for the efficient adoption and use of ICTs.

In order to take full advantage of the benefits of ICT for innovation and development, policies need to be designed and implemented to target the most important market failure that hinders the diffusion of these technologies: the coordination failure (Aghion, David, and Foray, 2009). Coordination is particularly important for the diffusion of technologically complex systems such as ICTs. One of the major benefits of ICTs is network externalities, where the gains of using the technology by each individual user increase with the total number of users.

To achieve these benefits, connectivity platforms and interoperability standards in telecommunications and information systems must be adopted. The lack of policy coordination in this area leads to the proliferation of standards and a market populated by devices that are incompatible with one another, leading to the dissipation of network externalities.

Platforms and interoperability standards are only part of the equation. Network externalities also come about through the co-evolution of technology on the supply side and applications on the demand side. It is the mix between technology development and applications that unbundles the impacts of ICTs throughout society.[26] This requires policies that reduce transaction costs and related appropriability problems that make coordination between suppliers and users difficult. Two areas where there are coordination problems between suppliers and users are infrastructure investment and human capital development. Users might decide that the best strategy is to wait until someone else makes the investment in order to gain access to the infrastructure or the human capital at a lower cost.

Tackling the coordination problems that hinder the diffusion of ICT technologies in the LAC region requires a systemic, multi-stakeholder approach focusing not only on supply considerations, such as platforms, interoperability, and standards, but also on problems affecting demand. Unfortunately, the region has a way to go before adopting a holistic approach to ICT policy making. Deficits in policy coordination remain in the following areas: the scope of ICT policies, access, e-government, e-education, e-health, and e-business.

Scope of ICT Policies

Some of the specific deficits in policy coordination have to do with the scope of ICT policies:

(i) Current ICT policies in the region show a strong bias toward the development of e-government, particularly in the areas of financial management, procurement, and the management of tax and revenue systems. They often ignore the capacities of the private sector to adopt and use ICT technologies, particularly the lack of specialized human capital and the low level of digital literacy. Comprehensive policies should be designed that reach out to various segments of the population in the public and private sectors as well as civil society organizations.

(ii) Almost all ICT-related public policy in the region focuses on the support and development of the supply of ICTs, with scant attention to incentives for developing demand, especially mechanisms that facilitate the matching of demand with supply.

[26] 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.

Box 7 | ICT in Latin America and the Caribbean, or How to Arrive Late to a Technological Revolution

Access to new information and communication technologies by Latin American and Caribbean countries 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 when analyzing 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 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 sector has benefited from lower costs for users, thanks in part to 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 the local ICT industry, with enormous payoffs.

Source | Navarro, Llisterri, and Zuñiga, 2010.

(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 capacity, but little attention has been paid to institutional strengthening for the design and implementation of ICT policies. A cursory 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 limited, and operational budgets are restricted.

(v) LAC governments have made only limited use of public-private partnerships to implement their digital agendas. Because the private sector is generally more agile than the public sector, it might be possible to accelerate implementation of ICT policies by outsourcing some of it to private firms. For example, e-procurement could be outsourced to a private operator that could invest in developing and operating the system, with reimbursement based on the number of transactions.

(vi) International coordination and cooperation is essential to promote

Box 8 | High-speed Networks Connecting LAC and OECD Research

CLARA (Cooperación Latino Americana de Redes Avanzadas) Network

- CLARA is an international non-profit 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. The IDB has provided financial support to the CLARA network, focusing on support for its institutionalization, with the expectation of consolidating a stronger high-speed Internet network in LAC and expanded, higher-quality links between computer networks in Europe and LAC (GEANT and CLARA).

C@aribNET

- C@ribNET is a computer network similar to CLARA, which fosters collaboration, research, and knowledge sharing between higher education institutions in the Caribbean, Europe, and the United States. This organization was created by the CARICOM Heads of State and received 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.

particular aspects of ICT diffusion and use. While some regional initiatives are moving forward (see Box 8), much more needs to be done.

Access Policies

In order to distribute the benefits of ICTs more equitably, the first challenge faced by policy makers is expanding access. A high rate of ICT diffusion improves the quality of human capital in a country, increases the demand for technological goods, and contributes to the democratization of political structures by increasing access to information. Recognizing that private connection is too expensive to reach the poorest segments of the population and in some instances even the middle classes, some countries have set up programs to promote collective access to ICT. Today, public access centers are the only means of access for many Latin Americans.[27] Despite progress, access policies in the region still face challenges, particularly in the following areas:

(i) The current capacity of the licensed spectrum is close to its saturation point. The region requires much more effective management of the spectrum, both licensed and unlicensed, with greater emphasis on use by individuals in order to sustain the increase in the demand.

(ii) Access needs to be increased. Increasing access will require widespread development of broadband networks.

[27] 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, results have been more positive. Chile and Colombia have made considerable progress in this area.

Box 9 | The IDB Broadband Development Platform: Broadband, Digital Agendas, and the Telecommunications Sector

Telecommunications is a crosscutting sector characterized by its multiplier effect on other sectors of the economy. The industry provides specific voice and/or data services through a telecommunications infrastructure. Achieving coordination between the services provided, penetration of the infrastructure, and the technical and economic feasibility of such services are becoming a major concern of governments around the world. Latin America and the Caribbean, however, have lagged behind in both the policy focus and the resources dedicated to promoting broadband connectivity throughout society and the economy. Even though the importance of the Internet and ICT is widely recognized, the latest developments in both technologies and business models unleashed by the expansion of broadband infrastructure in Europe, Asia, and North America have failed to be mainstreamed in Latin America and the Caribbean. Today, many businesses in the region cannot export or increase their productivity because of poor or low-speed connectivity. Researchers cannot process data. Governments cannot provide universal services to their citizens. Patients cannot receive the benefits of telemedicine or students the benefits of distance or computer-assisted education, because broadband connectivity is not available to the majority of them. At the current pace, broadband connectivity will take two generations to catch up with typical levels of access in advanced economies.

In view of the importance of this issue, in 2011 the IDB launched the Broadband Development Platform, a special initiative that will allow the Bank to focus technical and financial resources on engaging public and private entities in the region, at both the national and the sub-national levels, to take decisive action to accelerate the diffusion of broadband connectivity in Latin America and the Caribbean.

This initiative will translate into digital agendas which will include four main areas of action for governments and which define an action plan to use telecommunications as the backdrop for the development of other sectors: a) institutional strengthening and regulation, b) connectivity, c) public-private partnerships, and d) demand-side policies.

Institutional strengthening and regulation: The successful implementation of the action plan of the digital agenda depends first and foremost on the degree of government involvement and on how well the various ministries play their respective roles. In addition, success depends on the development of a robust regulatory framework, grounded on a clear understanding of the markets affected, either wholesale or retail, and on the operator(s) that may be defined as significant market power operators. Institutional strengthening requires, above all, extensive capacity building on the technical, economic, and legal issues associated with the functioning of the telecommunications sector. Only by understanding how the technical, economic, and legal issues impact each other will the telecommunications cabinets and national regulatory agencies be able to move forward. This is essential in order to prevent inefficient market structures that can unnecessarily restrain private sector investment and distort pricing to the point of creating barriers to affordable access by business and households.

Connectivity: The second pillar for the development of telecommunications services in general, and broadband services in particular, is connectivity. The telecommunications sector is capital intensive and is always under the umbrella of destructive innovation, which causes telecommunications operators to move on to new technologies before existing ones have been fully depreciated. Because the telecommunications sector is capital intensive, economies of scale and population density are key variables considered by telecommunications operators in their deployment plans. Worldwide, access is becoming a major issue when connectivity is discussed. In fact, there are different technological means to provide access to end users (FTTx, HFC, WiMAX, PLC/BPL, xDSL). Which one is eventually chosen depends on economies of scale and population density as well as on the degree and manner of competition in the relevant markets. The combination of these variables leads operators to provide services in specific areas where the expected revenues are greater than the costs but not in those regions where the costs are greater than the expected revenues.

Public-private partnerships: To avoid an increasing digital divide and achieve the goal of universal service, a public-private-partnership that guarantees universal access to telecommunications services is a requirement. Such a partnership would put in place a cross-subsidization framework to finance the supply of connectivity to rural, isolated, and poor areas. A key issue in the penetration and usage of telecommunications by all social strata is the price of the services. Thus, it becomes very important to review the tariff policy applied and, when required, to define a tariff framework that corrects existing deficits in access by some groups.

Demand-side policies: Last but not least, governments should work on specific initiatives aimed at encouraging the population—individuals, households, businesses and institutions in general—to adopt telecommunications services in their daily activities. In order to do so, a critical step is to increase not only the penetration of PCs but also the penetration of PCs connected to the telecommunications network. Specific training on the use of the applications should be provided to the population at large, so as to promote the use of hardware and infrastructure. Encouragement of innovation in services by businesses through the creative use of ICT should also be part of these demand-side efforts.

The development of these actions will be key for increasing the penetration and adoption of broadband services from the supply side as well as from the demand side. In order to guarantee that the traditional economy moves towards a digital economy, close coordination between telecommunications operators, regulators, and the government is recommended.

The lack of broadband networks critically affects rural communities, semi-urban areas, and the low-income population in 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 infrastructure. Operators are unlikely to develop networks in areas of slow return on investment unless these investments are subsidized. (See Box 9.)

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

(iv) The regulatory framework governing telecommunications needs to be upgraded in order to foster competition among providers of the latest technological solutions.

(v) The performance of the Universal Access Funds needs to be improved. At the regional level, these funds have reportedly disbursed less than 11 percent 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 to foster connectivity, due either to lack of technical competency or lack of access to these resources.[28]

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

Some of the issues in expanding e-government in the social sectors in the LAC region are summarized below:

(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 dramatically improve not only the internal management of the public sector but also the efficiency of service delivery. Also critical is the standardization of the technical criteria for system development and data definitions (metadata).

(ii) Information on e-government services available to the public should be disseminated and their use promoted.

(iii) In terms of e-education, broadband connectivity in schools should be

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

increased. For example, only 10 percent of schools in Argentina and Uruguay enjoy broadband connectivity. Alongside increases in connectivity, learning content and platforms for content access and assessment and student evaluation ought to be developed.

(iv) ICTs should be integrated into educational programs as a tool for teaching, learning, and student evaluation. Special emphasis will need to be placed on teacher training.

(v) Efforts to digitalize primary health care centers and hospitals are still embryonic. It is crucial to start with implementing electronic medical records, which is the foundation for improving health care management.

ICTs in Firms and e-Business

In addition to the factors preventing adoption of ICTs by firms described previously, some other policy challenges are:

(i) The need to increase the coverage and funding of ICT extension systems focused on increasing ICT literacy among small and medium enterprises (SMEs). SMEs need assistance in adapting new technologies and coordinating their requests for ICT applications.

(ii) The need for ICT applications and services focusing on SMEs.

(iii) The design and implementation of better financial instruments to make the acquisition of ICT equipment by SMEs viable. These instruments may include leasing, factoring, loan guarantees, and tax incentives.

Specific, limited initiatives are necessary but not sufficient to effectively promote ICT diffusion among Latin American firms. They should be embedded into each country's SME policy and digital agenda. Unfortunately, this rarely happens. An analysis of the digital agendas of LAC countries reveals an inclination toward the use of ICTs only as an instrument of social inclusion and development rather than as a factor in economic development (Peres and Hilbert, 2009).

Chapter III

THE IMPERATIVE OF INNOVATION
CREATING PROSPERITY IN LATIN AMERICA AND THE CARIBBEAN

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III. Bank Programs in Science, Technology, and Innovation

Since its establishment in 1959, the Inter-American Development Bank has been the largest provider 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 IDB's investment in 65 science, technology, and innovation (STI) projects was valued at US$2.2 billion, or close to US$5 billion if agricultural R&D and higher education are included.[29]

The IDB's support for STI cuts across many areas and activities, 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 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.

The Science and Technology Division

With the creation of the Science and Technology Division (SCT) in 2007, the Bank's analytical and operational capacity increased significantly, furthering the Bank's goal of supporting the design, execution, and evaluation of larger and more complex technological development and innovation programs in the region, 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 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

[29]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.

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, reversing the brain drain); incentives to increase collaboration in research; development and innovation (R&D+i) between universities, 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 an enabling 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

In general, 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. Specifically:

- 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 lines include 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 new instruments to support innovation by the private sector through horizontal matching grant 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), and guaranteed loans and credit lines for innovation in partnership with the private and public banking systems.

- Loans regularly finance human capital formation in S&T fields. They target the strengthening of scholarship programs for national and international graduate studies in science and engineering as well as attempts to make universities and technical schools more responsive to industry and local needs. The latter includes revising engineering programs to include entrepreneurship increasing their participation in international accreditation and quality-assurance systems. IDB loans regularly support initiatives to improve the teaching of math and science at lower levels of education, dissemination of good practices in technical and vocational education, pilot programs to encourage the hiring of young graduates in the business sector, and programs to enhance incentives for researchers.

- Loans for S&T infrastructure aim at the upgrading and development of the 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 and regional technical cooperation projects (TCs). TCs support loan preparation and address strategic policy priorities, such as strengthening STI institutions, promoting collaborative R&D initiatives and regional public goods, human capital formation, and the use of information and communications technologies to increase productivity and inclusion. Because of their small scale in terms of funding, TC projects generally seek to promote pilot initiatives that can have a demonstration effect.

Table 2 highlights some recent initiatives in the areas of innovation for social inclusion, regional innovation systems, and R&D capacity building.

With respect to knowledge and capacity building, one of SCT's main objectives is to be a knowledge leader in STI policy and to increase awareness of the crucial importance for LAC countries of investment in STI as a central component of their development agendas. The Bank is committed to developing STI indicators in all countries in the region, deepening understanding the impact of innovation investments on productivity and employment, evaluating STI policy instruments and institutions, and compiling and disseminating best practices in STI.

The project portfolio illustrated in Figure 19 highlights just a few of the IDB's current projects and loan operations in the region developed by the Science and Technology Division. The blue dots represent loans, the yellow dots represent country-specific technical cooperation programs, and the red dots represent multi-country regional technical cooperation programs. Figure 20 presents information about IDB support for most areas of policy intervention in science , technology and innovation, matching the description to the categories presented in Figure 13 in Section I. This serves to highlight the systemic and multifaceted nature of the Bank`s support for the sector.

The Division works hard to build linkages and networks of experts and practitioners as counterparts. The Regional Policy Dialogue's Science, Technology, and Innovation (STI) Network, an instrument created by the Bank's Board of Executive Directors in 2006, provides high-level policy makers from the region with a forum to exchange ideas, experiences, lessons learned, and to identify regional cooperative initiatives aimed at providing common solutions to the shared challenges faced by member countries.

Table 2 | **IDB Special Initiatives in STI and the MDGs.**

Initiative	Objective
Broadband Development for Competitiveness and Integration	This program supports five Central American countries in the design of public policies for broadband development, which are an essential complement for many other sectoral policies, especially public administration reform, health, education, productivity, trade, science, technology, and innovation. The program supports the following activities: a) design of a model to estimate the costs for infrastructure deployment; b) a profitability analysis for each type of deployment; c) an action plan combining initiatives on the supply side (public-private investment, tariff policies, subsidies, etc.), and on the demand side (subsidies for personal devices, digital literacy, creation of financing mechanisms, etc.); d) development of a stable and predictable regulatory framework; e) design of digital agendas to improve the adoption of ICT in public administrations, the private sector and civil society, aimed to increasing productivity and social inclusion; and f) institutional strengthening.
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 to gather empirical evidence on the potential social and economic impact that mobile telephones can have and to identify business models for scaling up these types of projects. For further information: www.iadb.org/mobilecitizen
Virtual Institute	The goal of this joint initiative between the IDB and Microsoft Research is to build local 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 in the areas 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.[30]

With over 10 meetings organized since its creation, the IDB's STI Network has provided an ideal space for the sharing of knowledge and best practices between member countries. It has also served as an efficient platform to identify and support concrete initiatives that have strengthened south-south cooperation. Activities include the financing and coordination of exchange visits between countries and the preparation and execution of regional technical cooperation projects, such as

[30] 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. A joint IDB-OECD publication comparing Latin American and OECD regional innovation systems will be issued.

Figure 19 | **SCT's Project Portfolio**
Each Dot Marks an IDB/SCT Project that Promotes Innovation in the Region

comparable indicators and assessment of policy instruments. Recently, the IDB has joined efforts with OECD, ECLAC, and SEGIB to develop a stronger regional network on innovation policy, including the joint organization of meetings and the development of a shared policy research agenda.

SCT also supports special initiatives (see Table 2) 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 Box 10), the Bank's loans to Argentina and Uruguay included components aimed at leveraging technology and innovation for social inclusion.

Figure 20 | **How the Science and Technology Division Supports Innovation Policy Instruments in Latin American Countries**

Instrument	IDB Science and Technology Division Supportive Actions / Country
Supply instruments	
S&T Funds	Mainstream policy instrument designed and financed in most IDB lending programs in science, technology and innovation (Argentina, Colombia, Chile, Guatemala, Nicaragua, Panama, Uruguay, Paraguay, Peru, and Venezuela).
Support to centers of excellence	The IDB has supported the development of a center for research and technology on logistics in Panama, and a center for, Biomedical Sciences and Biotechnology which will be the first institute of the Max Planck Society in South America, among other initiatives aimed at bringing about or strengthening centers of excellence in the region.
Scholarships for undergraduate, graduate and postgraduates in S&T	Standard component of lending operations, aiming and creating a critical mass of human capital needed for the development of the national innovation system (Argentina, Colombia, Ecuador, Panama, Peru, Uruguay, and Venezuela).
Support for national graduate programs in S&T	Natural complement of actions in the line above. Sometimes in a second stage of a long term program (Colombia, Panama, Paraguay, and Peru).
Salary incentives to research in S&T	Bank operations have supported the design of these kinds of incentives. A recent example is the case of Panama.
Affiliation with national researchers abroad	Design and funding of efforts to link the scientific Diaspora to the home country (Peru, Uruguay).

Instrument	IDB Science and Technology Division Supportive Actions / Country
Demand instruments	
Technology and Competitiveness funds	FONTAR (Fondo Tecnologico en Argentina) in Argentina. This fund is designed with the intention of improving the competitiveness of the private sector through technological innovation. It supports the execution and evaluation of innovation projects.
Venture capital and other financial funding for firms	Many of the loans in the science and technology division designate a line of funding, either credits or subsidies, that provides financial support to firms that are starting or continuing innovation projects, research and development programs, and/or technological development projects.
Fiscal incentives for R&D	The bank has produced policy analysis in this area, which has served to provide advice to governments about best practices. Recently, the issue became the main topic of a major Regional Policy Dialogue event.
Promotion of technology and knowledge transfer (extension technology services)	A relative newcomer in the toolkit of Bank-funded innovation policy instruments. New lending programs being designed in Peru incorporate support for technology transfer centers such as CITEs (see Box 4). Another example is reimbursable support for technology services in Argentina.
Strategy and Articulation instruments	
Sectoral Funds	Growing line of interventions financed by the Bank. Lending programs active in Argentina and Colombia incorporate this kind of fund as major component.
Priority Areas Programs	Most Bank operations in the sector today have some ingredients of priority areas in which efforts concentrate. Examples include Colombia, Panama, Peru.
Innovation clusters, promotion of conglomerates, business incubators, etc.	The bank has been active in supporting clusters and technology-based incubation programs in Argentina, Brazil, Chile, Dominican Republic, Uruguay, and still others.
Mechanisms for enhancing regional innovation systems	The Bank has been developing lending operations for the support of innovation activities in the context of sub-national entities. Brazil and Mexico have ongoing efforts in this regard. More limited interventions of this kind have taken place in Colombia.
Coordination mechanisms between actors of National Innovation Systems (technology tables, innovation chambers…)	Support for this kind of instrument has occurred in the case of Uruguay and Venezuela, among others. Since 2006. More generally, the Division has financed major studies that support efforts by individual countries to enhance institutional arrangements in the science, technology and innovation sector. A highlight along this line of activity is the IDB support for the preparation of OECD`s Innovation Policy Review for Peru.

Box 10 | Connecting Technological Development and Social Issues: Crowd Sourcing gives People a Voice

Vulnerable populations are often excluded from access to social services, employment opportunities, and the policy-making process. Now, new technologies are giving them a voice to express their most urgent concerns so that ad hoc strategies aimed at addressing their needs can be designed. The expression "crowd sourcing" is the combination of "crowd" and "outsourcing" meaning that a crowd of users can participate in the design, implementation, and evaluation of an initiative through web technologies that allow them to provide input and feedback at any stage of the process.

The advantage of crowd sourcing is that those pieces of information that are deemed necessary for a successful project are collected not only in the initial design stage but also during execution, allowing continuous and incremental improvements. This makes the use of resources more efficient and allows people to express in real time whether they are benefiting from the project under implementation or if changes are needed. Moreover, the evaluation process, which sometimes starts at the end of a project, can now use and process the feedback information collected throughout all stages of the initiative, allowing a better understanding of the initiative as a whole.

The IDB's Science and Technology Division designed this flow chart, which depicts the main steps of an initiative based on crowd sourcing. The initiative "A World of Solutions: Innovations for People with Disabilities," developed and implemented by the Division, is a successful example of the use of crowd sourcing tools. This project focuses on giving a voice to people with disabilities, a vulnerable group that is among the most excluded of the region and that lacks access to education and employment.

The first stage of the project was the "Problems Competition" through a crowd sourcing site that allowed participants to post and present issues that could then be voted on by other users, essentially using a darwinesque approach to move the issues with the most votes to the top rank. The discussion and feedback surrounding the issues were facilitated through a blog moderated by two bloggers with disabilities who were responsible for creating additional space for discussion while making sure that the page was accessible to all.

The second stage was the "Solutions Competition," based on the five most popular problems identified, calling for proposals with innovative solutions to the problems. The participation was impressive: 1.6 million visits to the website from Latin America, Europe, and Asia, 150,000 votes for the top five problems (60,000 for "Software for People with Visual Disabilities," 44,000 for "Toys for All," 43,000 for "Access to Transport," 3,000 for "Educational Support for Deaf Children," and 2,000 for "Work from Home." The participatory process led to the identification of ten projects that are now under implementation and that are changing people's lives.

For details, visit: www.bidinnovacion.org.

Step 1 > Area of concern

An area of concern is characterized by a heterogeneity of issues that cannot be tackled through a "one size fits all" response. The contribution of all stakeholders is required in order to understand the complexity and generate ideas for solutions.

Step 2 > Giving people a voice

Identify problems: interactive websites or blogs allow users to express their needs. The Science and Technology team moderates the websites and identifies the priorities.

Identify the solutions: there are a world of ideas out there, why not ask the people? Coordinating a public debate can help to identify the ideas with the highest potential.

Step 3 > Interact with stakeholders

Stakeholders not only participate in the identification of priorities and responses, but they also play a key role during the implementation phases by providing advice and feedback in real time.

Step 4 > Learn and disseminate

Initiatives based on crowdsourcing represent an invaluable learning opportunity: there is no better way than learning from participants. The dialogue with the stakeholders allows the identification of best practices that can be adapted and replicated.

International Cooperation: Trust Funds for S&T and Innovation

Over the past 50 years, the IDB has established strong relationships with bilateral institutions and governments of non-borrowing member countries. This has 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 the IDB responds to emerging development challenges, the donor community and the IDB have agreed to focus on results, strengthen grant financing, and create strategic, thematic, multi-donor funds that target priority areas such as innovation and the knowledge economy, water, sustainable energy, and climate change.

Trust funds are an important source of non-reimbursable financial and technical assistance to partner countries for the implementation of development programs. They not only leverage financing for new initiatives by providing small-scale seed funds that can lead to more substantial funding, but they also serve as the main instrument for financing regional public goods and regional investment programs. Regional investment programs are particularly important in supporting capacity building in science, technology, and innovation.

Examples of trust funds in science, technology and innovation include the Italian Trust Fund for ICT for Development and the Knowledge Economy Fund (see Box 11), the Knowledge Partnership Korea Fund for Technology and Innovation, and the Chilean Trust Fund for Supporting Technological Innovation in Central America and the Dominican Republic. Examples of trust funds covering other areas but with implications for 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).

Box 11 | 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, known as the Knowledge Economy Fund. This fund underscores 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 provide. The government of Finland became the first contributor to the fund in 2009, and the government of Spain joined the fund with a contribution of its own in 2010.

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 to support key scientific, technological, and business actors, both national and regional, so that they can become fully integrated into worldwide knowledge networks. This goal is consistent with the core mission of the Bank, by contributing to advancing development goals linked to competitiveness and growth and those related to social development and welfare.

Nature of the Support Provided and Beneficiaries

During its two years of operation, the KEF has become a key source of flexible, non-reimbursable funding for the support of activities that promote S&T capacity and innovation. It plays 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. In 20 months the fund's operation has leveraged over ten times the amount of resources directly spent on its projects, and it has benefited all IDB borrowing countries.

The KEF constitutes a primary source of funding for regional projects that are multi-national in scope, although it is not limited to them. The fund's intended beneficiaries include the private sector, universities, educational and research institutions, and 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.

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Concluding Remarks

Innovation is an imperative for the development of more competitive and sustainable economies. This volume has shown the extent to which, despite some bright spots, Latin America and the Caribbean have fallen behind in building their technological and innovation capacity. This shortcoming severely impedes economic development and competitiveness in the modern knowledge economy. For the Latin American and Caribbean region, now more than ever innovation is one of the main avenues for addressing challenges such as slow productivity growth, lack of economic growth, and social inequality.

In a globalized world, innovation processes are occurring on an international scale and at an accelerated pace. Collaboration among countries and various actors, in the public as well as the private sector and academia, is not just desirable; it is a requirement to address global challenges such as climate change, the development of alternative energy sources, access to water and sanitation, poverty, and natural disasters. The integration of Latin American researchers and universities into international research and development networks is indispensible for understanding, using, and transferring new technological applications. For business, the internationalization of innovation carries with it the rapid expansion of the technological frontier in all areas of production, including manufacturing, services, and primary and natural resource-oriented activities.

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, make it the partner of choice in a process aimed at accelerating the region's ability to fulfill its potential and succeed in the global knowledge economy.

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