THE NEW IMPERATIVE OF INNOVATION

Policy Perspectives for Latin America and the Caribbean

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IDB

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Abstract

The main purpose of this study is to present the conceptual basis that supports science, technology, and innovation (STI) policy in Latin America and the Caribbean (LAC). It starts by clarifying STI relationship, both conceptual and empirical, to economic growth and it explains how market and coordination failures hinder innovation. Then, it discusses a variety of demand- and supply-side policies aimed at addressing these private sector and institutional insufficiencies. In the specific case of LAC, it examines the region's underperformance in innovation relative to both emerging and advanced economies, and analyses the degree to which scientific productivity and knowledge inputs have led to accelerated economic development. Finally, the publication presents five dimensions of success for STI policies based on international best practices that should stimulate innovation and economic growth and guide the IDB's work in STI in the region.

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Abbreviations

BRIC....Brazil, Russia, India, and China

CENIS....National Education Center of English and Systems, Colombia

ECLAC....European Commission for Latin America and the Caribbean

CID....Center for International Development

CORFO....Production Development Corporation, Chile

COLCIENCIAS....Admin. Dept. of Science, Technology and Innovation, Colombia

CORPOICA....Colombian Agricultural Research Corporation

CTI....Competitiveness and Innovation Division

FIA....Foundation for Agricultural Innovation, Chile

FIP....Fisheries Research Fund, Chile

FONSOFT....Fund for the Promotion of Software Industry, Argentina

FONTAR....Argentine Technology Fund

FONTEC....National Fund for Technological and Productive Development, Chile

GDP....Gross Domestic Product

GNP....Gross National Product

ICM....Millennium Science Initiative Program, Chile

ICT....Information and Communications Technology

IDB....Inter-American Development Bank

IFI....International Financial Institutions

IFC....International Finance Corporation

I-Lab....Innovation Lab

INE....National Institute of Statistics, Chile

INTA....National Agricultural Technology Institute, Argentina

LAC....Latin America and the Caribbean

NBER....National Bureau of Economic Research

OECD....Organisation for Economic Co-operation and Development

ORP..Office of Outreach and Partnerships

OVE..Office of Evaluation and Oversight

PROSOFT...............Programme for the Development of the Software Industry, Mexico

R&D..Research and Development

RICYT...Red de Indicadores de Ciencia y Tecnología (Network of Indicators of Science and Technology)

SITRA..Finnish Innovation Fund

SME..Small and Medium Enterprise

STI..Science, Technology, and Innovation

TC..Technical Cooperation

TDF..Technology Development Funds

TEKES.......................................Finnish Funding Agency for Technology and Innovation

UNSECO...........................United Nations Educational, Scientific and Cultural Organization

USSR..Union of Soviet Socialist Republics

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Foreword

Encouraging innovation is a daunting task. Innovation depends on many diverse elements coming together, including a vibrant scientific community, financial markets open to funding new ideas and corporate research laboratories. An innovative ecosystem cannot be built overnight. While many governments have launched well-intentioned programs to promote innovation, they have frequently encountered disappointments if not outright failures.

The experience in Latin America and the Caribbean (LAC) is no exception. According to the 2014 Global Innovation Index, Chile led the major LAC countries in innovation, but placed only 46th of the 143 countries evaluated. Brazil (61st) lagged two of the other BRIC (Brazil, Russia, India, and China) countries, with China at 29th and Russia at 49th. Success in creating an innovation ecosystem is not merely a matter of national pride. Over 50 years of empirical studies suggest that innovation plays a critical role in economic growth. It is therefore critical that the governments, policy-makers, and development finance institutions involved in setting LAC's growth agenda understand the barriers to creating an innovation economy in the region.

This publication makes a major contribution toward this goal by exploring the challenges to science, technology, and innovation (STI) policy in LAC. It builds a foundation to support the importance of STI, illustrating its conceptual and empirical relationship to economic growth. It also provides a nuanced picture of the innovation process and stresses the critical importance of a coordinated effort among all stakeholders. The authors distill decades of research to explain how market and coordination failures inhibit innovation, especially in developing markets such as those in the LAC region. To address these private sector and institutional deficiencies, this publication considers a variety of demand- and supply-side STI policies. It highlights the need to match such strategies with the constraints of each individual economy, and clearly articulates lessons learned from analyzing case studies of different programs.

The authors also explore the region's underperformance in innovation relative to more advanced economies. To do this, they use widely known and accessible metrics, such as country-level investment in research and development (R&D) as a percentage of gross domestic product (GDP) and the proportion of this investment funded by the private sector, researchers as a proportion of the labor force, and doctorates in science and engineering per capita. The publication also explores the extent to which progress in scientific productivity and knowledge inputs in the region has translated into commercially valuable technologies.

The authors reflect on the Inter-American Development Bank's (IDB's) efforts to spur STI development in LAC to date. They advocate that investments in STI must become a top priority and include institutional support for the key stakeholders in the innovation ecosystem. The publication's five dimensions of success for STI policies touch on well-established, international best practices that, if properly executed, should accelerate innovation and economic growth in the region. While general guidelines are established to direct work in the region as a whole, much care is taken to note the heterogeneity among countries.

This publication will serve as an important resource in organizing policy initiatives and confronting the region's challenges moving forward. By establishing the critical need for evidence-based STI policy and clearly illustrating the state of LAC's landscape in STI relative to global benchmarks, this research will no doubt contribute to advancing the state of thought regarding future innovation initiatives.

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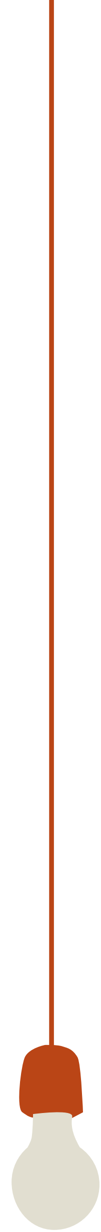


Introduction: The Need for a Conceptual Framework for Innovation Policy in Latin America and the Caribbean

Science, technology, and innovation (STI) have a pervasive and growing presence in all human activity. Accordingly, the Latin American and Caribbean (LAC) region is expected to incorporate STI as an expanding part of its investment and economic reform programs and, more specifically, in areas such as energy production and consumption, environmental protection, agricultural production, transportation, commerce, public administration, education, health care, and social policy. Such development reflects well-established worldwide trends toward increasing knowledge and innovation density in national economies.

Governments play a critical role in enhancing competitiveness by directly encouraging business innovation, by establishing an enabling environment for firm innovation and technology-based entrepreneurship, and by providing complementary public goods such as scientific knowledge and advanced human capital. Policies and programs that address market and coordination failures and support the development of national innovation systems seek to raise productivity and strengthen competitiveness. The ultimate goal of public policy in this sector is thus to enhance business productivity and competitiveness in the LAC region by facilitating the creation and growth of dynamic firms with the capacities and tools to innovate and compete in international markets. Putting together the architecture for the pre-conditions of scientific, technological, regulatory, and connectivity of such enhancement is also a key part of what the IDB does and this document covers.[1] In providing guidance toward this goal, the IDB developed a Sector Framework Document (SFD) on Innovation, Science and Technology. This publication breaks down most of the technical content of that document so that the main lines of the IDB's thinking on STI can be better disseminated in the hope of providing useful input for policy dialogue.[2]

[1] Discussing science and technology policy in the same context as innovation policy is standard in the literature. The main source of reference for the modern definition of innovation—OECD's Oslo Manual (OECD and Eurostat, 2005: 6)—defines innovation policy as "an amalgam of science and technology policy and industrial policy. Its appearance signals a growing recognition that knowledge in all its forms plays a crucial role in economic progress, that innovation is at the heart of this 'knowledge economy."

[2] The Bank's regulations state that the SFD should provide flexible guidance to accommodate the diversity of challenges and institutional contexts faced by the Bank's 26 borrowing member countries and should be narrow enough to provide meaningful guidance to project teams, while providing a clear sense of what the Bank seeks to accomplish in a given sector. The particular SFD that served as a resource for this publication addresses this mandate for STI, establishing a framework for the IDB's work in the sector, including operations, research, and dialogue with countries. The official SFD document can be accessed at *http://www.iadb.org/en/sector/science-and-technology/sector-framework,18415.html*

The rest of this publication is structured into three sections. The first presents international empirical evidence on policies and programs in STI. LAC's experience with policy-making in STI provides a major source of such evidence, but state-of-the-art analytical and assessment literature focused on other regions of the world is also used when relevant. The next section provides an analysis of the challenges faced by the region and, in light of current research, identifies priority action areas for the IDB. The final section deals directly with the role of the Bank in supporting innovation, science and technological development. The authors review a series of evaluations of IDB projects, presenting the main lessons learned in the course of its extensive work in the sector, discussing the Bank's institutional strengths as a provider of financing and technical assistance, and defining guiding principles and priority areas for future action.

Innovation, Scientific, and Technological Development and Economic Growth

Innovation and Knowledge as Keys to Productivity Growth and Economic Development

Innovation is 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,[3] increased productivity, and economic progress.[4]

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 are the agents in charge of transforming knowledge into new economic solutions for their own benefit and the economy as a whole.[5]

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.

Beyond the simple accumulation of labor, physical, and human capital, innovation is a key determinant of long-term growth by improving the ways in which capital and labor combine and consequently improving the yields for the same level of productive factors. Empirical evidence shows that about half of the variation in income levels and growth rates among countries is due to differences in total factor

[3] The inescapable reference on this point is Solow (1957). Using American data from 1909 to 1949, Solow found that 87.5 percent of the doubling in gross output per man hour was attributable to technical change, while the remaining 12.5 percent was attributable to increased use of capital.

[4] A key implication of this definition is that innovation is not a synonym for scientific research or technology. In practice, it is often associated with them, but there is a wealth of non-technologically based innovation, as well as scientific results and even technology that does not necessarily translate into innovation. Innovation is firm based and is about new ways of doing things that add value. In contrast, invention shows how to do something and that it is feasible.

[5] For a discussion of the link between innovation and firm productivity see Cohen (2010).

productivity (Hall and Jones, 1999). Previous research found that investment in R&D[6] explains up to 75 percent of the differences in total factor productivity growth rates, once externalities are considered (Griliches, 1979). Evidence from OECD countries shows that investment in R&D spurs 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.[7]

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 to R&D have been estimated at 40 percent or more (Hall, Mairesse, and Mohnen, 2009). In addition to generating new knowledge, investments in innovation also have a direct effect on creating absorptive capacity. Innovation activities, particularly R&D investment, are fundamental to developing new competencies and the skills needed to seek, acquire, and adapt existing technology. In other words, innovation activity is a key driver of catching-up to more advanced economies (Rostow, 1960; Cohen and Levinthal, 1989).[8] In fact, in advanced economies, returns to R&D investment tend to increase with the distance to the technological frontier (Griffith, Redding, and Van Reenen, 2004).

Even more importantly, social rates of return on innovation exhibit the same pattern in developing economies (Benavente, De Gregorio, and Nuñez, 2005) and some estimates find them to be even higher. Lederman and Maloney (2003) found that the social returns to 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. For relatively poorer countries, such as Nicaragua, some estimates put the average return closer to 100 percent. More recent research has introduced some caveats, finding that rates of return to R&D follow an inverted U pattern (see Box 1), increasing with distance to the frontier and then falling after a certain point, turning negative for the poorest countries. This phenomenon is attributed to the absence of a critical mass of complementary inputs for innovation, such as adequate human capital, scientific infrastructure, private sector development and sophistication, and coordination of the innovation system (Goñi and Maloney, 2014).

[6] R&D investment is commonly used as a proxy for investment in innovation because it can be relatively well measured and, conceptually, it constitutes a measure of the financial effort that countries put into new ideas in their economies. More precise measurements of innovation beyond R&D have only recently become available for a limited number of countries.

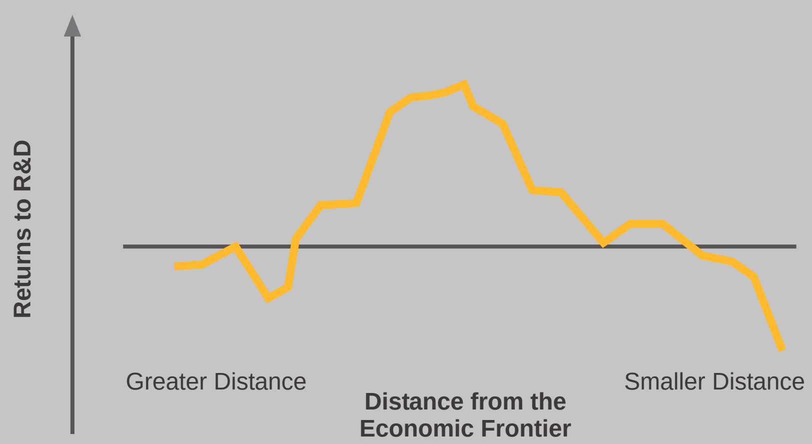
[7] The main point made here is not intended to imply that there is absolutely no effect of growth on innovation. For nuances in this regard see Griliches (1986), Hall and Mairesse (1995), and Goñi and Maloney (2014).

[8] The importance of knowledge and technological capabilities for catching up has been extensively documented (Griffith, Redding, and Van Reenen, 2004). This was the case not only for Japan in the early 1930s (Johnson, 1982), but also for the 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).

Box 1. The Relationship Between Rates of Return to R&D and Stages of Economic Development

Research by Lederman and Maloney (2003) found that rates of return were higher in countries with lower levels of economic development (as measured by GDP in purchasing power parity (PPP) per capita). Those findings suggested that countries could take advantage of being behind the technological frontier by adapting or using technologies developed at the frontier presumably at a lower cost. Recent analysis by Goñi and Maloney (2014) found evidence of an inverted U relationship between returns to R&D and stages of development (as measured by distance to the economic frontier). This implies that there is a point at which countries fall out of range and higher returns to R&D for economies that are a great distance from the frontier (e.g., the less developed economies in the LAC region) begin to dissipate. The authors concluded that this is most likely due to lack of complementary capacities (i.e., human capital, scientific infrastructure, and all the characteristics of a national innovation system) needed to efficiently absorb technology.

Figure 1. Rates of Return to R&D and Distance from the Economic Frontier



Source: Based on findings from Goñi and Maloney (2014).

Many signs point to the fact that such important contributions of knowledge and innovation to growth are expanding at an accelerated rate. Increasingly, today's economies are 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 have already become a major determinant of their ability to function and compete. Traces of these trends are everywhere:

investment in knowledge-related activities and intangibles has been growing faster than capital investment in advanced economies for at least a decade (OECD, 2013a). The knowledge content of products and services is on the rise all over the world. The labor market shows a growing skills bias in both developed and developing economies, signaling that jobs growth will be in those occupations that involve sophisticated handling of symbols, information, and analysis.[9] 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 STI (Rand Corporation, 2007). This has been the case for the better part of the past two decades.

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 technology (ICT).[10] Indeed, given that ICT substantially lowers the cost of information storage and transmission, its diffusion throughout the economy reduces the uncertainty and transaction costs associated with economic interactions. Such technologies increase the organizational capacity of firms to codify knowledge that otherwise would remain hard to store, organize, transmit, and use, accelerating learning and reducing problems related to "organizational forgetting" (Foray, 2007). Production processes can be decentralized more easily, meaning that different components of the same processes can be located in different countries based on the comparative advantages of each economy, resulting in major reconfigurations of global value chains (Lach, Bartel, and Sicherman, 2005). On the demand side, the ICT revolution facilitates a higher degree of customization, opening new possibilities for developing countries to exploit emerging niches through e-commerce technologies. ICT shortens the distance between producers and users: buyers and sellers located in different cities, regions, and countries can share information on needs and products, reducing information asymmetries and market entry costs (Perez, 2008). This, in turn, leads to an increase in the volume of transactions, generating more output from the same set of inputs. In other words, ICT has triggered higher productivity levels (Spence, 2001; Chen and Dahlman, 2005).

Yet, for all the development and potential of contemporary connectivity, the fact remains that innovation still takes a very long time to spread to most firms in developing countries. Available practical experience and recent research indicate that it is one thing to have the technology available, but quite another to incorporate it

[9] This is does not necessarily mean that investments in innovation are bound to produce rewards only for the highly skilled, or that innovation is inherently labor saving and therefore incompatible with job creation. Analyzing Latin American economies, Crespi, Tacsir, and Vargas (2014) found that product innovation tends to lead to employment expansion in firms through the development of new production lines needed for the new products, although process innovation can lead to job cuts at the firm level. More generally, assuming innovations for a given market take hold in a particular firm or set of firms in a developing country far from the technological frontier, such innovation can have an aggregate expansive effect on employment by turning firms more competitive, leading to expanding sales and exports.

[10] A recent estimate indicates that there was an eighteen-fold increase in internet traffic across borders between 2005 and 2012 (McKinsey Global Institute, 2014).

into the productive process. Not only does the public good nature of knowledge stand in the way of smooth and rapid catching-up in terms of technology, but also very real factors prevent efficient dissemination of innovations. Although new ideas and inventions are reported ever more rapidly in today's interconnected world, it is a well-established fact that mere availability and sometimes even awareness of how better to produce or organize things is a far from sufficient condition for adopting new ideas and know-how in practice, in production, and in the economy. Adopting and absorbing existing technological innovations is an uncertain and risky process that is costly for firms and requires accumulation and assimilation of both physical and human capital (Nelson and Pack, 1999; Comin, Hobijn, and Rovito, 2006).[11] In addition, a significant share of the knowledge important to the economy and development is tacit, meaning that it cannot be codified, explicitly documented, or transmitted outside direct personal interaction. It consists of competencies without formal comprehension, which represents often overlooked and formidable obstacles to knowledge diffusion.

The result is a widening productivity gap between advanced and developing economies (a valid generalization for LAC [Pagés, 2010][12]) and the uncontested fact that global innovation is highly concentrated in a small number of nations around the world, which does not include LAC countries.

The remainder of this chapter discusses how to better frame and understand this problem and how government responses have fared in tackling its causes and improving the state of innovation in the LAC region. The argument proceeds step-by-step from the systemic nature of innovation and the foundations of the ability of public intervention to influence innovation, to what to do, what is being done, and to what effect in matters of innovation policy and its close relative, science policy.

Innovation as a Systemic Process: The Determinants of Innovation

The growing literature on innovation systems 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 (see Box 2, illustration a); rather, it is a collective process involving interactive learning among several actors (e.g., researchers, firms, and

[11] An extensive literature documents the extent to which distance, language, and cultural barriers can stand in the way of the diffusion of innovations. See Rogers (2003) for a review.

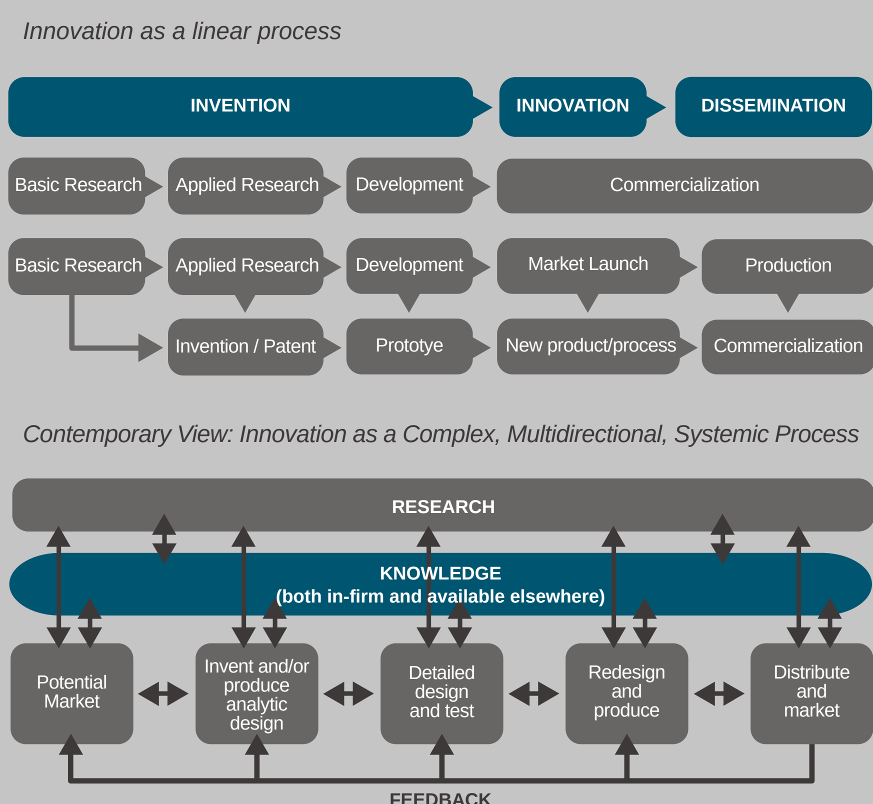
[12] In *The Age of Productivity* (Pagés, 2010), the IDB, through a comprehensive research project, firmly established the severity of the productivity gap affecting LAC (see in particular Chapter 2, Daude and Fernandez Arias, 2010). The fact that STI deficits have become a major factor behind widespread slow productivity growth across the region was explicitly addressed in Navarro, Llisterri, and Zuñiga (2010). Later, the point was confirmed and explored in Crespi and Zuñiga (2010).

users) and requiring multiple inputs (e.g., research, training, production facilities, engineering, problem-solving at the plant level, and marketing) (see Box 2, illustration b). 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 (e.g., firms, universities, public agencies, governments, financial systems, and markets) contribute to generating, disseminating, using, exploiting, adapting, and incorporating knowledge 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. (Kline-Rosenberg, 1986).

Box 2. Linear vs. Non-linear (Systemic) Views of Innovation

Increasingly, innovation is seen as an endeavor that requires multi-actor involvement (private, public, and academic) as well as conducive channels through which information and resources can move freely, such as university–industry linkages, financial institutions, and markets, to name a few. The following figure illustrates the different viewpoints of innovation as a linear process and as a systemic process.

Figure 2. Different Views of Innovation



Source: Saenz-Arce and Uquillas (2005).

Left to Their Own Devices, Markets Tend to Produce a Sub-optimal Level of Innovation[13]

Knowledge as a Public Good

A businessman will invest less than optimally in figuring out a new productive process or in improving the technical skills of his personnel if his competitor can easily steal his ideas or well-trained human resources without having invested in bringing them about. Ever since the seminal works by Nelson (1959) and Arrow (1962), knowledge has been considered a non-excludable[14] and non-rival[15] good. When innovators cannot take advantage of all the benefits associated with knowledge creation, a gap arises between social and private returns from related investments and, therefore, there is less investment in knowledge generation than is socially desirable. The natural response to this issue, on the face of it, is to establish a system of property rights that maximizes the social returns of knowledge production and dissemination. Yet there are trade-offs between, for instance, strong patent protection and technology diffusion (with its associated benefits in terms of aggregate productivity gains and social welfare benefits)[16] that make designing and enforcing an optimal regimen extremely difficult.[17] Yet it turns out that the public good nature of knowledge is only one of several market failures associated with innovation.

Asymmetric Information

The economics of information literature (Stiglitz and Weiss, 1981) indicates that asymmetric information in market transactions (associated with problems of adverse selection and moral hazard) can influence business innovation in several ways. First, innovation projects have unique characteristics that exacerbate the typical problems of asymmetric information and hinder the financing of all investments (Hall and Lerner, 2010). One of the reasons is that innovation projects are riskier than most

[13] What follows constitutes a presentation of the pervasive market failures affecting markets for knowledge and technology. In doing this, we follow the standard treatment of the matter in the literature. It is worth noting, however, that in exceptional circumstances, market conditions can be such that the market produces a considerable level of investment in innovation, enough to make it roughly equivalent to the socially optimal level. Imagine, for instance, a firm that moves first into an untapped market made possible by, say, a new technological development or unprecedented business model, and the conditions of the relevant market are such that its first mover advantage cannot be easily erased for a relatively long time by any other competitor, creating incentives for the first mover to keep investing in perfecting, scaling up, and complementing the initial innovation. Even beyond this, if a group of firms detects the possible exceptional pay off of market conditions such as these, the possibility of excessive innovation investment cannot be ruled out in exceptional conditions.

[14] The non-excludable characteristic of knowledge refers to the difficulty of maintaining exclusive possession of it while using the knowledge.

[15] The non-rivalry characteristic of knowledge refers to the possibility of it being used simultaneously by many after it is produced because it lacks physical constraints.

[16] For an analysis of an instance of such trade-offs as related to barriers to the availability of pharmaceuticals in developing nations, see Cockburn, Lanjouw, and Schankerman (2014). For a discussion of the incentive issues involved in intellectual property rights systems, as informed by the evolution of the U.S. patent system, see Jaffe and Lerner (2007).

other projects.[18] Also, because of the inherent difficulties in avoiding leakages in the knowledge created, innovators are reluctant to share information about their projects with potential outside investors. This further magnifies the problem of asymmetric information. Also, it is difficult to use intangible assets as collateral. In summary, a gap tends to exist between the normal opportunity cost faced by private sector innovators and the minimum capital cost that they are charged by external investors in order to finance their innovation projects. Since this is a pervasive and multifaceted problem, the result is that a good share of all potentially profitable innovations falls by the wayside.

Additionally, private actors, both producers and users, do not have perfect information about the possibilities that a new technology offers. Normally, the person providing the technology has more information about its potential than the one about to acquire it. Given the problems of adverse selection and moral hazard associated with the asymmetric information that affects technology transactions, their distribution ends up being slower than it might otherwise have been. This concurs with two findings of remarkable empirical robustness, introduced above:

(i) There are persistent differences between countries regarding technological performance, meaning that keeping up to date is far from being the automatic process that the idea of knowledge as a public global good might suggest (Fagerberg and Verspagen, 2002).

(ii) The process of technological dissemination, even within narrowly defined industries, is very slow and produces persistent differences with regard to firms' productive performance (Disney, Haskel, and Heden, 2003).

Institutions Are the Key: Coordination Failures

The most recent literature on innovation systems emphasizes that the knowledge that underpins any innovation always has critical tacit components, and it is therefore very difficult for innovation to emerge without the necessary feedback and close interaction between various actors (Lundvall, 1992). Although many of these interactions occur as a result of market transactions (e.g., when a firm purchases new machinery and receives technical assistance from the supplier), other interactions are governed by different institutions, thereby giving rise to potential coordination problems (Soete, Verspagen, and Ter Weel, 2010). A good example of this kind of

[17] Typically, the incidence of this type of failure increases when knowledge is more generic and decreases when knowledge is more applied, since a good share of productive knowledge is idiosyncratic to any particular firm. The general trend goes in the direction of more serious underinvestment in science and pre-competitive research than in development within firms. Given a considerable degree of complementarity between both types of knowledge creation, this trend constitutes a major rationale for science policy.

[18] Beyond risk, there is inherent uncertainty attached to innovation projects, understood as the unfeasibility of attaching probabilities of future events associated with the outcomes of investment. This operates as a powerful deterrent for potential funding sources for innovation initiatives.

problem is the development of software applications for small and medium enterprises (SMEs), which usually requires close interaction between the developer and the user because of the limited absorption capacity of the user (Cohen and Levinthal, 1989).[19] In a scenario in which scale is limited and clients highly heterogeneous, transaction costs can end up hampering the emergence of a software service market oriented toward SMEs. By establishing user consortia to coordinate demand and by regulating minimum product standards, this limitation might be alleviated. In more general terms, there will very often be a serious obstacle to putting a new technology into practice in any productive environment if appropriate regulations and coordination that are indispensable for joint investment on complementary assets (specifically human capital and distribution chains, among others) are absent (Bresnahan and Trajtenber, 1995; Aghion, David, and Foray, 2009).

The Innovative Firms that Fail to Exist

Current literature provides ample support and empirical evidence for the notion that entrepreneurship is important to private sector development and economic growth. In addition, recent research has shown that fast growing firms could have a significant impact in terms not only of productivity and innovation (Haltiwanger, Jarmin, and Miranda, 2013; Kane, 2010; Acs and Audretsch, 1989; Audretsch and Keilbach, 2003; Holtz-Eakin and Kao, 2003), but also in terms of job creation, since evidence indicates that small and young firms may contribute to job growth more than established, older, larger firms (Haltiwanger, Jarmin, and Miranda, 2013; Criscuolo, Gal, and Menon, 2014). The latest developments in ICT have made these issues more prominent than ever for decision-makers. Traditional thresholds to business development in key areas such as entry costs, access to talent, suppliers, clients, marketing channels, and means of payment have been lowered, and business models have been globalized and radically transformed through access to broadband communications and software applications. Firms located anywhere can have global aspirations and very rapid growth in a way unthinkable just two decades ago. Yet, due in part to the same kind of market failures identified above and a series of governmental and regulatory obstacles, dynamic, high-growth, technology-based entrepreneurship does not flourish spontaneously (Wagner and Stein, 2014). Worldwide, however, the type of entrepreneurship born out of identifying market opportunities rather than out of plain need for income (or self-employment) is becoming a major focus for both private investors and public policy (Lerner, 2012).[20]

[19] Absorption capacity refers to the likelihood that, before exploiting new knowledge, users must jointly invest in human capital or seek direct help from the originator (Steinmueller, 2010). In other words, a given firm's pre-existing relevant knowledge is a key factor its ability to capitalize on investments in technology, new equipment, or external knowledge in general (Cohen and Levinthal, 1989).

[20] The literature has come to designate these two varieties of entrepreneurship as necessity driven and opportunity driven. The most common form in LAC is by far necessity-driven, comprising most of what is usually understood as the vast informal sector in most economies in the region. All references to entrepreneurship issues in this book belong rather to the opportunity-driven kind, since, when productivity growth through innovation is the focus of either public policy or private investment decisions, only high-quality ventures with high potential for fast growth harbor a real possibility of contributing to economic growth and significant employment creation (Shane, 2009).

Special Issues in the Market for Innovation in Developing Countries

In addition to the list of market failures outlined above, the following are particular obstacles to innovation in developing economies:

(i) Weak linkages between firms or poor performing intermediary companies create huge information gaps and compromise the quality of the value chain as a whole.

(ii) Absorptive capacity tends to be endemically low, making it difficult for firms to extract the full potential of investments in new equipment or external knowledge.

(iii) Markets and firms tend to be smaller than they should optimally be, which prevents them from taking advantage of economies of scale (e.g., larger firm size is highly correlated with larger investments in R&D).

(iv) Scarcity of complementary products in many markets creates unnecessarily high uncertainty about the ability of firms to produce and market new goods (Greenwald and Stiglitz, 1989).

(v) Scarcity of specialized managers, knowledge brokers, technicians, and engineers well versed in certain industries or technologies make it difficult to diversify the economy or to take firms to the next level in terms of product sophistication and quality.

(vi) Good management practices have often not spread across firms to the same extent that is common in advanced economies (Bloom and Van Reenen, 2010).

(vii) The emergence of new innovative firms is constrained by the weak market incentives that exist or the paucity of public policies to help them overcome obstacles to innovation such as those listed above.

Still another issue that is particularly hard to deal with in developing countries is directly related to their lower degree of institutionalization compared to centuries-old public and private institutions that is typical of advanced economies. In a weak or incomplete institutional environment, getting the most out of investments in innovation becomes a challenge. Furthermore, acting and getting results in institutional change is often relatively more difficult and slow paced in developing countries than in developed economies.

Finally, social issues such as poverty, social exclusion, and access to education and health care are especially prominent in most developing countries. With scarce resources, these social issues may leave little room for innovation as a sector of public policy. Serious long-term competitiveness and productivity issues run the risk of being neglected. A response to this state of affairs has been the notion of social innovation, which points to the potential of technology- and non-technology-based innovations to address and provide solutions to social issues. Mostly based on applying open innovation platforms and methods to social issues directly relevant for the base of the pyramid, several programs around the world and in LAC in particular (e.g., *Ideas para el Cambio* in Colombia, a COLCIENCIAS program) are turning innovative thinking into the source of practical solutions for the poor and excluded. This approach addresses widely felt problems with a renewed perspective and helps spread the word that technology and innovation are important not just for firms and research institutions, but also for society at large. This, in turn, has the potential to impact public decision-making in the direction of wider and more consistent support for STI policy in the long run, a major issue in the policy-making process in the sector.

Public Policies Are Necessary to Achieve Efficient Innovation in the Economy

Market failures associated with innovation activity represent, worldwide, a compelling rationale for public intervention to foster productivity growth by encouraging firm innovation. Under the market conditions typical of developing economies, knowledge gaps regarding specific market distortions create the need for a deliberate, policy-based, search process (Hausmann, Rodrik, and Sabel, 2008) and suggest a strong case for active STI policies (Crespi, Fernández-Arias, and Stein, 2014). Such policies can address market failures by developing programs in areas such as incentives to business innovation, value chain upgrades, business incubators and accelerators, venture capital market development, industrial cluster strengthening, or talent acquisition (highly skilled migration). The combination of innovation and trade policy also belongs in this discussion. According to the existing literature, there are significant feedback effects between innovation on one hand and export and foreign investment on the other (Aw, Roberts, and Yi Xu, 2008; Girma, Gorg, and Pisu, 2008).

Two general modalities of intervention exist. First, investment in innovation at the firm level (individual firms or a group of firms linked in a value chain or a cluster) can be directly encouraged. Second, framework conditions (e.g., improving the availability of key inputs for innovation) that lead to increased levels of innovation activity in the economy as a whole can be addressed. Both firm-oriented and framework-enhancing policies are consistent with higher and sustained productivity growth. Further, both can be horizontal if they apply to the whole economy or vertical if they concern a particular economic sector, value chain, or industrial cluster. Table 1 illustrates the quadrants resulting from this typology and provides a partial list of policy interventions included in each quadrant. Allowing for the particular circumstances of each economy, all four groups of interventions are potentially relevant for LAC (Crespi, Fernández-Arias, and Stein, 2014). A brief discussion of the main policy instruments involved follows.[21]

Table 1. STI Policy in Four Quadrants

Scope		Type: Horizontal	Type: Vertical
Scope	Public Good	• Higher education and training • Support of scientific research • Intellectual property rights • Research infrastructure • Human capital immigration • Labor training • Competition policy • Regulation • Technology transfer organization • Entrepreneurship education • Intellectual property rights and bankruptcy legislation and regulation • Innovation climate • Improve deal flow through technology transfer • Tax policy	• Technological institutes (e.g., agriculture, industry, energy, and fishing) • Standardization • Thematic funding • Signaling strategies • Information diffusion policies (extension systems) • Technological consortiums • Contests • Industry-specific training programs
Scope	Market Intervention	• R&D subsidies • R&D tax credits • Financial measures (e.g., guarantees for technology investments and intangibles values) • Adoption subsidies • Public financing of seed, angel, and venture capital, directly or through private venture capital funds • Generic business incubators and accelerators • Tax incentives	• Public procurement • General purpose technologies (e.g., ICTs, biotech, and nanotech) • Strategic sectors (e.g., semiconductors, nuclear energy, and electronics) • Defense sector • Business incubators and accelerators focused on a particular strategic sectors (e.g., ICT or biotechnology)

Source: Crespi, Fernández-Arias, and Stein (2014).

[21] Space limitations prevent us from presenting a discussion of the whole set of instruments, design and implementation issues, and the evidence pertaining to their effectiveness and impact. For an extensive discussion, see Crespi, Fernández-Arias, and Stein (2014), particularly chapters 3, 4, and 7.

Using Horizontal Interventions to Influence Firm Behavior

Support for firm innovation is a generally accepted governmental practice around the world. In OECD countries, between 10 percent and 45 percent of manufacturing firms[22] receive public support for innovation in any given year through a variety of channels that include direct transfers and tax credits. Fiscal incentives for innovation are an established practice in a few countries in Latin America (e.g., Colombia, Brazil, Chile, and Uruguay) (see Parra Torrado, 2011 for details), but the instrument of choice across the region tends to be innovation funds that allocate resources to private firms for innovation projects on a competitive basis. A long list of reasons derived both from innovation policy (e.g., better targeting and additionality, accessibility to SMEs, and transparency) and fiscal policy (e.g., the simplicity of the tax code and moral hazard) show the superiority of direct subsidies over fiscal incentives.[23]

Direct subsidy programs are often described as demand-based interventions since the government does not choose which firms to support, but waits for the firms to reveal their demand for innovation and then awards the funds. As a standard design feature, such programs require that beneficiary firms provide matching funds. Ample evidence supports this type of policy intervention as consistently effective in Latin America. Past IDB evaluations have shown that innovation funds that have direct subsidies as their typical policy instrument are effective (Hall and Maffioli, 2008; see Lopez, 2009 for a comparative discussion of thirteen evaluations of programs of this kind in LAC). In particular, these evaluations 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 and innovation. A study of the effects of this type of subsidy on SMEs in Colombia over the medium term (Crespi, Maffioli, and Meléndez, 2011) showed that COLCIENCIAS (Colombia’s Administrative Department of Science, Technology and Innovation,) funding not only had a positive impact on investments in innovation by firms, but also had a significant impact on their performance. The study provided evidence that these effects persisted and, in some cases, increased over time.[24] Beyond their impact on productivity, innovation funds have proven to be fiscally rewarding, allowing for an increase in tax revenue because of expanded revenue generated by innovative firms, which is usually larger than the total cost of the government funds supporting innovation policy (Lopez, 2009; Rivas [Gerardo], 2010).

[22] The focus on manufacturing innovation reflects only the far better availability and comparability of data for innovation processes and outcomes in manufacturing firms, a bias shared by data bases available both in LAC and the OECD. This should not obscure the fact that innovation in the service and natural resources sectors are equally relevant for the discussion, and the generalizations made here apply to them as well. We provide more on innovation in those areas of economic activity later in this book.

[23] International and Latin American experience indicates that well-designed tax exemptions for R&D activity can minimize risks and costs relative to alternatives so that they become a part of a good policy mix (Crespi, 2012).

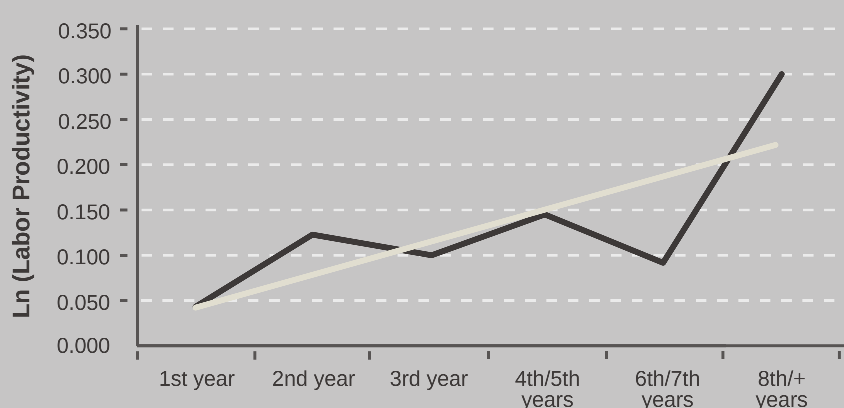
[24] Recently, considerable attention has been paid to the relative advantages of direct subsidies compared with tax credits as alternative channels of public support for firm innovation. The current trend in advanced economies is to favor tax credits, although policy research tends to find that direct subsidies have clearer and stronger effects on firms (OECD, 2013a).

Of particular interest are the effects on productivity. Between 1995 and 2007, COLCIENCIAS funding had an average impact on the introduction of new products of 12 percent and labor productivity of 15 percent, with these effects becoming more significant between three and five years after the firms received the funding (Crespi et al., 2011). These findings imply not only that beneficiary firms become more efficient, but also that they grow more and gain a larger market share than the control group. The result is that economic resources are being reallocated toward more productive firms, hence positively affecting productivity in the aggregate (see Box 3). Castillo et al. (2014) found ways to estimate the spillover effects of innovation grants to Argentinian firms in the context of the FONTAR program. They showed that not only firms that became direct recipients of the subsidies but also firms that in time hired personnel leaving the beneficiary firms improved their productivity, thus providing the ultimate rationale for public intervention, the presence of positive spillover effects (see Box 4).

Box 3. The Positive Impact of Innovation Funds:

The time lags between support and impact on firm behavior and performance are usually one of the major issues when considering incentives for business innovation. Support for innovation is expected to increase the innovative efforts of firms receiving funding and, down the line, productivity levels. As described above and illustrated in the graph below, evaluation of the matching grant program for firms in Colombia indicated that increases in productivity can come long after the initial investments to support innovation are made. In the figure, the line in black represents the percentage degree to which the SMEs with matching grants from COLCIENCIAS outperformed the control group. The grey line illustrates a smoothing effect for the data over the years considered in the study.

Figure 3. Impact of COLCIENCIAS Matching Grants on Firm Productivity (percent differences compared to the control group)

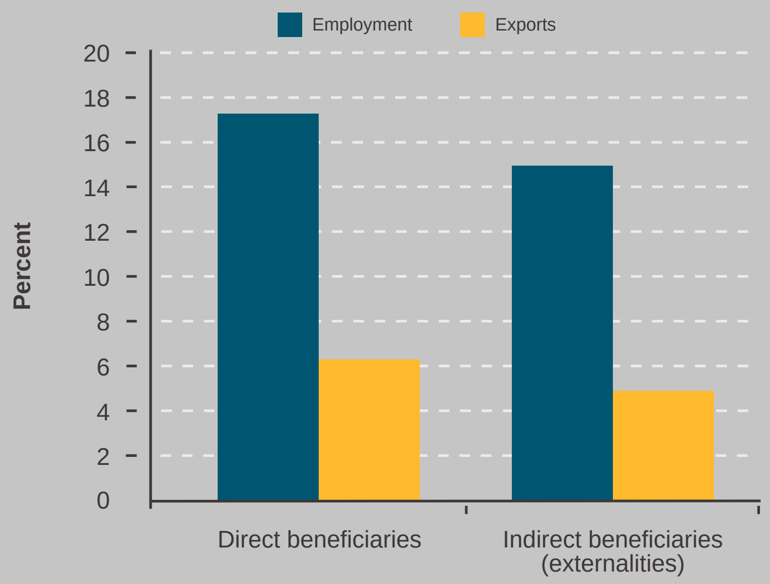


Source: Crespi, Maffioli, and Melendez (2011).

Box 4. The Positive Impact of Innovation Funds:

A common argument in favor of public support for firms to innovate is that there are positive spillover effects that go beyond the walls of the individual firms that have received public support. Although sound empirical evidence is scarce, very recent analysis of an extensive employer–employee matched panel dataset for the entire population of firms and workers from 2002–2010 in Argentina explores the effects of innovation funds on direct beneficiaries and positive spillovers to indirect beneficiaries. The rich dataset allowed knowledge diffusion to be tracked by observing the mobility of highly qualified workers from a beneficiary firm (a recipient of FONTAR funding) to other firms (non-recipients). Also, performance measures in terms of employment growth and exporting probability could be evaluated after some time. The findings published by Castillo et al. (2014) confirmed a lag between when the funds were received and the eventual payoffs because the performance measures were found to be increasingly positive over time. Further, there were positive spillover effects for Argentinian firms that were not direct beneficiaries of the FONTAR program.

Figure 4. Employment and Export Growth in Direct and Indirect Beneficiaries: Evaluation of FONTAR in Argentina



Notes: The analysis was also carried out over an eight-year period (2002–2010) with signs of how the relationships may have changed a few years after firms received funding.

Source: Castillo et al. (2014).

In sum, innovation funds that subsidize private sector innovation are, as long as they have been subject to rigorous impact assessment in the case of LAC, one of the most consistently effective public policies when it comes to making firms more knowledge intensive.[25] Experience indicates that this kind of policy instrument can be mastered and competently handled even in a context of weak institutions. In this case, the recurrent dilemma of requiring strong institutions in order to have efficient policies that are not distortionary or captured in developing countries can be considered almost a non-issue.[26]

Tiptoeing Away from Horizontal Policies

More recently, governments have chosen to provide some strategic direction to innovation funds by dedicating at least some proportion of the funds available to firms active in particular industries (e.g., energy, agriculture, and electronics) or technology areas (e.g., information technology and biotechnology) deemed vital or of high potential in the economy. This creates some variation of sector-specific innovation funds. Brazil, Mexico, and Argentina have a good deal of experience in this type of funding already and other countries in LAC are quickly catching-up.

This evolution in policy is the result of internalizing the fact that many public inputs needed for innovation are also sector specific (e.g., there is no such a thing as a "generic" engineer). When well-implemented, vertical policies are generally being done while preserving the demand-based approach, thus mitigating risks of capture or the inefficient approach of trying to pick winners. Recent impact evaluations (Crespi, Fernández-Arias, and Stein, 2014) suggest that the effects on technology exports and employment can be positive, although probably not immediately, and avoiding capture by research institutions can be a challenge.

Programs organized around the notion of clusters often also focus on technology and innovation and are increasingly combined with efforts to strengthen regional and municipal innovation systems. The growing space that innovation and technology occupies in almost any industry and product makes this a trend that is easy to understand. Deliberate attempts at integration in global value chains are not new as public policy in Latin America—consider the *maquila* industrial zones—and have had a measure of success. However, they have also had some very limited results in terms of knowledge transfer to the local economies. Recently, attempts have been made to upgrade global value chains by deliberately moving toward the value-added stages (i.e., beyond physical production, which turns out to be the lower value-added

[25] The literature on this kind of policy instrument in advanced economies tends to fall on the side of the dominance of positive impacts, but the room for disagreement is larger than for LAC. For instance, sector analysis of incentives for business innovation has found significant crowding out effects (Popp and Newell, 2009); methodological issues have also been raised. For discussion of the general assessment of the effects of these programs in developed countries see Klette, Moen, and Griliches (2009).

[26] See the section *Lessons Learned from the IDB's Operational Experiences* later in this book for a review of the Bank experience that supports this point.

phase), which means strengthening areas such as engineering, design, distribution and logistics, marketing, servicing of manufactured products, and R&D.

These types of innovation policies include a role for direct foreign investment in R&D, as well as strengthening domestic suppliers by investing in technological upgrades for firms. They also involve some deliberate effort to concentrate public support on certain clusters or value chains that have some desirable properties in terms of their potential to become springboards to enter more dynamic and knowledge intensive sectors. This represents still one more step in the direction of vertical policies to support firm innovation and productivity.[27]

The Special Case of Supporting Entrepreneurship

Beyond public programs aimed at encouraging innovation in established firms, governments around the world are also deploying a wide variety of interventions aimed at financing the creation and growth of dynamic entrepreneurs and high-growth ventures. As a response to the striking achievements of these instruments in the Silicon Valley, seed, angel, and venture capital funds have mushroomed over the past decade. Silicon Valley and a few other success stories speak eloquently about the role that government interventions play in making them possible (Lerner, 2009). Yet, the difficulty in replicating these successes in spite of sometimes very large investments by several countries suggest that both design (the difficulties public sector agencies have in adapting to the flexibility characteristic of new ventures) and implementation issues (e.g., poor supervision and cumbersome processes in providing financing) are not easy to get right. This has been the case in Latin America in spite of some partial achievements (Lerner, Leamon, and García-Robles, 2013). One lesson learned is that success in setting up a financial framework for dynamic entrepreneurship critically depends on the interventions that have been complemented by non-financial support programs, such as training, incubators, accelerators, adequate intellectual property rights, tax regimes, and technological resources. In turn, these programs are complex to design and quite often small details in the incentives implicit in a particular program can make a difference when it comes to results. A recent impact evaluation of CORFO's (Chile's Production Development Corporation) incubator program shows the importance of such small details (Navarro, 2014).

Investing in the Inputs for Innovation and the Role of Science Policy

In contrast to demand-side interventions aimed at encouraging firm innovation, supply-side policy instruments focus on generating new scientific knowledge, both basic and applied, and the formation of human capital as well as the necessary infrastructure to practice science and advance technology and its applications. Most

[27] Developing vertical instruments clearly places the methodological issues of identifying the economic sectors worth supporting on the forefront of policy. For an extensive discussion, see Crespi, Fernández-Arias, and Stein (2014). See also Hausmann et al. (2011) and Kim and Nelson (2000).

LAC countries currently have supply-oriented policies on their agendas (e.g., scholarship programs and direct funding for research institutes). This policy approach was the main component of science and innovation policy from the 1950s until the mid-1980s (Sagasti, 2011).

The traditional instruments used to promote scientific research include science and research grants, which evolved almost everywhere into a competitive, peer-reviewed process, along the lines of the National Science Foundation in the United States. Creating 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 worldwide in a selection of fields that are determined to have priority and relevance for the national economy. Their creation frequently involves a combination of resources, subsidies, and grants from both federal and local budgets. Three examples of this are the *Iniciativa Científica Milenio* (ICM or Millennium Science Initiative) in Chile, the program for *Centros de Excelencia* (centers of excellence) launched recently by Peru's CONCYTEC (*Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica* or National Council of Science, Technology, and Technological Innovation), and the *Centro de Excelencia en Genómica* (Center of Excellence in Genomics) in Colombia. These centers of excellence can be understood as vertical supply-side interventions, in contrast with the horizontal nature of the traditional peer-reviewed research projects.

Infrastructure for Science and Technology

For infrastructure, policies include developing university and public research centers with the right infrastructure in a variety of scientific disciplines but, most importantly, in general purpose technologies (specifically biotechnology, nanotechnology, and ICT) that underpin work in a wide range of more specific fields. There is extensive experience and well-established good practices in how to design and implement policy for scientific infrastructure and equipment, emphasizing relevance, adequate use of capacity, inter-departmental and inter-institutional sharing of sophisticated equipment, and provisions for maintenance and cost-recovery when possible. Often, universities turn out to be the beneficiaries of these policies.

Human Capital for STI

Policy instruments for human capital for STI 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. Worldwide, national talent acquisition strategies have become proactive. Traditionally, strategies focused on scholarship programs; however, this is now being complemented by a more deliberate and wider search for talent. More attention is being paid to developing domestic graduate and research programs that will be able to accommodate new doctorates returning from abroad. Additional 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. Thus, countries such as Argentina, Colombia, Ecuador, and Uruguay have put in place well-funded initiatives to attract and connect with the scientific diaspora. "Brain circulation" has replaced the old concept of "brain drain", thanks to the unprecedented mobility of people and ideas made possible by increased facility of transport and communication technology over the past couple of decades. Gradually, the notion that LAC countries must attract highly skilled human capital—not only scientists, but also engineers and entrepreneurs—is gaining traction: the celebrated Start-Up Chile program aims to attract entrepreneurs from around the world in the hope that their presence in Chile will help transmit tacit entrepreneurial knowledge to local entrepreneurs in a way that would be impossible through traditional training and scholarship programs. Still another new set of programs inserts researchers into industry by subsidizing the hiring of engineers and scientists with advanced degrees. Such programs are subject to a gradual phasing out of the subsidy until, after a few years, the firms eventually bear all the costs of the highly qualified personnel.

Focusing on Mission-Oriented Research: Vertical Science and Technology Policies

In general terms, as far as science policy is concerned, a better balance between applied and basic research in science funding and education programs constitutes a necessary first step toward better matching of investments in research with industry needs. This does not mean completely excluding basic research, but rather striving to balance discovery-driven research and mission-oriented research. Initiatives to support creating specialized research centers that address industry needs are again expanding in LAC. In some countries, these centers were created as far back as the 1930s but are lately being re-launched or re-structured so their governance and mission can be better aligned with industry needs and thus receive stronger funding. *Instituto Nacional de Tecnología Agropecuaria* (INTA or National Agricultural Technology Institute) in Argentina and *Centro Educativo Nacional de Inglés y Sistemas* (CENIS, National Education Center of English and Systems) in Colombia are two examples. In Colombia, *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA or Colombian Agricultural Research Corporation) seeks to generate and transfer scientific knowledge and technological solutions to the agriculture sector, with the aim of becoming the leader in research and innovation and contributing to the articulation of the national innovation system and the integration of local teams with international networks in science and technology.

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. A country's competencies in certain industries or technologies may still be embryonic but the sector may be deemed strategic for future economic performance (e.g., semiconductors and nanotechnology). *Fondo Fiduciario de Promoción de la Industria del Software* (FONSOFT, Trust Fund for the Promotion of the Software Industry) in Argentina and CT-BIPOTEC in Brazil are examples of such programs. Other 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, such as *Fondo de Tecnología Agraria* of the *Programa de Innovación y Competitividad para el Agro Peruano* (INCAGRO-FTA, Agricultural Technology Fund of the Competitiveness and Innovation Programme for the Peruvian Agriculture), *Fondo de Investigación Pesquera* (FIP, Fisheries Research Fund) and *Fundación para la Innovación Agraria* (FIA, Foundation for Agricultural Innovation) in Chile, and other programs targeting crosscutting areas.[28]

Programs to support crosscutting areas include creating funds to sustain technological development in technologies or sectors that have an impact throughout the economy and society (e.g., ICTs and environmentally friendly technologies). Some programs established to support crosscutting sectors include CT-AEREO and CT-ENERG in Brazil, and the *Fondo Sectorial para Investigación y Desarrollo Tecnológico en Energía* (Sectoral Fund for Technology Development in Energy) by *Consejo Nacional de Ciencia y Tecnología* (National Council for Science and Technology) (CFE-CONACYT) in Mexico.[29] Priority area programs are designed to support science and technology activities for social development. Activities include mobilizing human and financial resources for R&D, which is frequently done by specialized national research centers, and disseminating cost-effective technologies that have broad application in society. Some examples of research and project funding are the *Financiadora de Estudos e Projetos* (Financier of Studies and Projects) by *Programa de Tecnologias para o Desenvolvimento Social* (Technology Program for Social Development) (FINEP-PROSOCIAL) and FINEP-HABITARE in Brazil, and the Sectoral Fund for Research and Development in Water CAN-CONACYT in Mexico.[30]

These are all examples of vertical public goods–oriented science and technology policies. It is too soon to see concrete results from such instruments; however, some interesting recent examples provide grounds for optimism. Brazil and Argentina have successfully implemented sector policy initiatives in agricultural exports, and Mexico's PROSOFT (*Programa para el Desarrollo de la Industria del Software*) is an example in the software industry (ITAM, 2012). These efforts emphasized collaborative processes between public research institutions, technology transfer, extension services, export promotion, and industry.[31] A similar synergy is developing in the agricultural machinery industrial cluster in Argentina (Lengyel, 2009).

[28] This book does not expand on the particulars of the important area of innovation in the agricultural sector, even though most of the discussion on market failures applies to that sector. A detailed discussion can be found in the Agriculture and Natural Resource Management sector framework document (available in the IDB website http://www.iadb.org/en/sector/environment-and-natural-disasters/sector-framework,18387.html), which focuses on promoting rural development by creating effective policy interventions, technological innovation policies being one of them.

[29] Brazil has two important horizontal funds: VERDE AMARELO, which aims to strengthen R&D linkages between universities and firms, and FUNTTEL to develop telecommunications.

[30] Significantly, most of these programs bear the name of the specific economic sector for which they are intended to be relevant, signaling the very embodiment of the notion of mission-oriented research as contrasted with curiosity-oriented research.

From a Good Business Climate to a Good Innovation Climate

Beyond investment in inputs to innovation in the form of physical and human capital, ongoing developments in innovation policy emphasize the need to build a cultural, regulatory, and institutional environment that breeds innovation. The innovation ecosystem, an expression once reserved for the financial framework needed for technology-based entrepreneurship (comprising seed capital, angel investors, and venture capital), is now been applied in a more comprehensive way to refer to efforts that include anywhere from business accelerators and incubators to contests and prizes for outstanding innovators. In between lay the key institutions needed to solidify links among the main actors in the innovation systems, such as capabilities in intellectual property rights management, technology transfer offices at universities, and science and entrepreneurship education in K–12 and higher education, most of which to some extent depend on public policy but also require active private sector engagement. This type of policy approach goes beyond the traditional business climate reforms—as represented by The World Bank's Doing Business index—in the sense that they are based on the principle that leveling the playing field by creating a favorable business environment, no matter how important it is and how well it is done, will not take an economy very far in terms of sustaining competitive advantages and closing productivity gaps. That will require active productive development and innovation policies as well as the right environment for high-productivity companies to exist and prosper.[32]

Technology transfer programs that use public funding to help bridge the gap between ideas and prototypes originated in universities and the market are important members of this family of policies. So are institutions and programs whose mission it is to help 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 science and technology (OECD, 2013a). Technology diffusion centers (typically funded through public resources or combinations of private and public contributions) provide technology extension services that can help strengthen firms' capacities. They provide expertise and services, including but not limited to prospective studies, adaptation of foreign technologies, engineering services and development (i.e., testing new products, calibration, and quality tests), and training and networking services (i.e., with technology providers and customers, and with other industries).

Insofar as institutions govern the coordination of human interactions, the latest literature on innovation places great emphasis on good governance and institutional reform. For example, the literature favors institutional designs that promote

[31] For instance, in connection with technology transfer initiatives that try to link firms, government, and academia for the purpose of technology commercialization, see the experience of WIPO with CATI (*Centros de Apoyo a la Tecnología y la Innovación*) in WIPO webpage available in http://www.wipo.int/tisc/es/.

[32] Empirical support for this principle can be found to some extent in Halward-Driemier and Pritchett (2011), Stenholm, Acs, and Wuebker (2013), and Crespi, Fernández-Arias, and Stein (2014).

public–private interactions and that connect the different actors participating in the innovation process (e.g., firms, universities, a variety of public agencies, producers and users of new technologies, and consumers). This greater coordination can be achieved either by defining new roles for existing institutions (e.g., allowing universities to claim intellectual property rights over the research they conduct or regulating new contract models that support the emergence of a risk capital industry) or by creating organizations to regulate interactions between actors (e.g., by creating governing boards that induce coordination among a variety of public sector ministries or agencies and the private sector, competitiveness councils, university technology transfer and intellectual property rights offices, technical and quality standards-setting agencies, and public–private technological development consortia) (Steinmueller, 2010). These kinds of arrangements can lead to more innovation and high productivity growth because innovation policy becomes streamlined and better coordinated. Investments are not wasted on duplicate efforts that lead to overlapping results, ultimately, at the firm level, because products and services are more likely to be coordinated and more compatible across industries and within each industry's value chain. Thus, externalities become internalized and it becomes more likely that joint investments turn out to be complementary.

The Special Case of Innovation in Services and ICT

Worldwide, the prominence of services is being observed and studied as one of the most drastic changes in the economic structure since the emergence of the industrial revolution (Rubalcaba, 2007). Despite often being considered an innovation-averse sector, evidence from OECD countries shows a strong relationship between innovation and productivity in services firms. Moreover, some types of services are more knowledge intensive and innovative than manufacturing firms (OECD, 2009c). The majority of firms in LAC work in the service sector, and by far most of the employment is concentrated in this heterogeneous set of economic sectors (from retail to transportation and from finance to consulting), which are grouped in national accounts as services. Yet, traditionally, most of the discussion and research about innovation has manufacturing as the focus of attention and analysis. The standard Oslo Manual definition of innovation includes innovation in productive processes, organization, and marketing, which recognizes that innovation in services can happen and can potentially be important. Although innovation in services is still in the early stages as a subject of systematic study (see Box 5 for recent IDB research on the topic), it is generally recognized that:

(i) it depends less on R&D than innovation in manufacturing;

(ii) it often focuses on business models and business strategy, and is therefore rather low-tech;

(iii) when it comes to technology, the most important modern technology tends to be ICT applications, leading the literature to characterize ICT as the general purpose technology for the service sector (Savona and Steinmueller, 2013);

(iv) this is particularly important, and by no means exclusive, of the services known as 'Knowledge Intensive Business Services' (or KIBS), such as consulting, engineering and design.

Box 5. Innovation in Services in LAC

To accelerate growth and catch up with industrialized economies, increased productivity in services is a key challenge in the region (Pagés, 2010). Besides the negative effect of the sector by itself, the poor performance of these activities impacts economies in many ways. Low productivity in traditional services, such as transportation or wholesale, affects the whole economy, since these services connect the different stages of production. Furthermore, the lack or underperformance of knowledge-intensive business services (KIBS) firms harms the innovation capabilities of the rest of the economy, since KIBS are often co-producers of innovations with firms from other sectors (Hertog, 2010).

There is very little evidence on this subject for LAC (Tacsir, 2011), but during 2012, the IDB's Competitiveness and Innovation Division conducted a research project to improve understanding of innovation and productivity in LAC services firms. The project covered traditional services and KIBS in nine LAC countries, using different methodological approaches. Case studies analyzed the development of rural tourism and the software sector in Argentina; logistics, mining services, retail, and off-shoring services in Chile; eco-tourism in Costa Rica; cultural services in Jamaica; and biotech services in a multi-country study. Impact evaluations were performed to estimate the effect of public financial support programs for services firms in Argentina, Chile, Colombia, and Uruguay. Finally, quantitative studies, making use of data from national innovation surveys, applied the model developed by Crépon, Duguet, and Mairesse (1998) to analyze services in Brazil, Chile, Colombia, Mexico, Peru, and Uruguay.

The main findings of this project can be summarized as follows[33]:

a) The service sector is highly heterogeneous regarding innovation activities and performance. Only a few LAC service firms are close to the technological frontier; however, higher productivity firms are not growing. There are inefficiencies in allocating resources that are harming aggregate productivity levels (Arias-Ortiz, Crespi, Rasteletti and Vargas 2014).

[33] More details can be found in Crespi, Tacsir, and Vargas (2014).

b) Services firms are as innovative as manufacturing firms, but innovation strategies are different. Service firms rely less on R&D and more on other innovation activities, such as training, software, licenses, and know-how acquisition), compared to manufacturing firms.

c) The size of a firm is less relevant to investing in innovation in services firms. This suggests that there are less fixed costs in innovation-related activities, but access to financing remains a key obstacle. Furthermore, innovation in services is more open. It is based on external inputs and demands higher levels of cooperation.

d) Technological innovation has a strong and positive impact on productivity in services firms; however, non-technological innovations could be very, and perhaps even more, relevant for improving performance.

e) Services firms are less likely to receive public financial support for innovation, especially in the case of the traditional services. This is mainly because the design of innovation programs is biased toward R&D and other technological investments that are less relevant for services firms.

These results should be taken into account when designing innovation programs because the nature of services intensifies some of the market failures that hinder innovation investments. Even when fixed costs are less relevant than in manufacturing, it is crucial to ease access to financing for innovation. Innovation support programs, as currently designed, are biased toward manufacturing-type innovation. To increase participation of service firms, programs should be flexible enough to include support for softer inputs for innovation. All in all, there is little doubt that countries can effectively increase productivity in services by encouraging innovation.

Finally, measuring innovation activities in services needs to improve. Innovation surveys should extend coverage to all services activities, but also incorporate questions that capture innovation investments that are related to non-technological innovations.

As in other areas of technology diffusion and adoption, ICT does not spread throughout the business landscape, and particularly among SMEs, as smoothly and rapidly as desirable. As such, productivity in the service sector, on average, is maintained at abysmal levels, as shown in recently emerging research (Chong, 2011; Crespi, Fernández-Arias, and Stein, 2014). Firms face several obstacles in adopting ICT technologies. First, there are high fixed costs associated with purchasing and maintaining hardware and software and adapting it to production processes, which disrupts 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 ICT) prevents firms from adopting these technologies and fully realizing their potential benefits. Finally, services provided online and the coordination between them and transport and mail infrastructure are still limited and their regulation is embryonic, consequently reducing the attractiveness of adopting ICT. Business analytics, using social media for marketing and customer relations, and intelligently managing inventories and deliveries, just to mention a few examples, are rarely known or practiced in most SMEs in developing countries, and LAC economies are no exception. Broadband deployment, essential for most of these advanced uses of ICT in business, lags behind across the region.

The Special Case of Innovation in Natural Resource Industries

LAC countries are heavily endowed with natural resources. The traditional view in the development literature has been that abundance of natural resources tends to be a mixed blessing, creating potentially large risks as well as opportunities. In spite of having a rich tradition of applied research and technology diffusion, the agricultural sector, in particular, has been associated with backward production methods and slow productivity growth. Yet, the recent decade of structural transformation has increased the importance of natural resources in the majority of LAC countries (CIEPLAN, 2013). Since the early 2000s, the terms of trade of commodities have increased by more than 40 percent above their long-term trend, and in several LAC countries this price boom has led to substantial investments to expand the production frontier of natural resource sectors (both renewable resources such as agriculture and non-renewable resources such as mining). This is partially due to excellent external conditions, such as growing demand for raw materials from China and India, and the boom in commodity-based resource sectors. To a large extent, these productivity gains have been driven by the impact of ICT in the reconfiguration of natural resource value chains at the global level, as well as by the introduction of product, process, and business model innovations directly related to natural resource anchor firms and the network of SMEs that act as suppliers of services and technology to them (see Box 6). The dynamics of innovation in sectors such as agriculture and mining is still not fully documented or understood, but its relevance for LAC makes it a major focus of STI policies.

Box 6. Natural Resources: A New Path for Knowledge-Based Development?

Globally, and in keeping with the new possibilities afforded by the deployment of ICT, the traditionally vertically integrated global value chains in the natural resources sectors are being reconfigured as new production routines are established based on outsourcing and subcontracting. Together with changes in the production function, demand has induced the rise of new sectors of knowledge intensive suppliers that serve special demands from large natural resources companies. In developed countries with significant natural resources, such as Finland, Norway, Canada, and Australia, these suppliers, some of them producing goods such as zero tillage machines for agriculture or services such as drone-generated information for plague controls, are evolving to satisfy growing demand for new technology and innovation in natural resource sectors (OECD, 2006). Indeed, these companies provide solutions for technological and organizational problems faced by natural resource intensive firms. For instance, developing a new type of paper brings together a diverse range of new expertise in fiber, biotechnology, chemistry, engineering, business management, logistics, and software development. For many natural resource firms, these skills are beyond their internal capabilities and are thus provided by specialized firms. What the evidence from developed countries suggests is that reliance on natural resources can foster economic growth when underpinned by efforts to increase technological innovation and accumulation of capabilities to innovate around these resources. Specialized knowledge-intensive supplier firms developed around these industries are central not only for innovation and technology diffusion across the natural resource base, but also for diversification toward related higher-value products and activities (Figueiredo, 2013).

This new understanding matters for policy-makers in LAC because the changes in world conditions provide resource-rich countries with a new window of opportunity to use abundance in natural resources to fuel new knowledge-intensive sectors and to use them as a source for productivity growth. There is some circumstantial evidence that the above-mentioned trends are also showing up in LAC. For example, in the Chilean mining industry, a new cluster of small and medium suppliers has shown itself to be highly dynamic. Indeed, according to Fundación Chile, there are around 800 knowledge-intensive suppliers in the sector, and exports of mining engineering services have grown from US$10 million in 2000 to US$400 million in 2012 (OECD, 2013b). Similarly, although less spectacular, trends are observed in animal health services for aquiculture, also in Chile, in bio-informatics for ethanol in Brazil, non-traditional exports (mango) in Peru, traceability services for meat exporting in Paraguay and Uruguay, agronomy services for transgenic crops in Argentina, among many others. However, despite these encouraging developments, preliminary analysis focused on the mining and agricultural industries suggests that several market failures (particularly coordination, regulation, and externalities) hinder the development of linkages between natural resource–based sectors and innovation intensive firms such that the actual market outcome might be less than optimal. This opens a new space for innovation policy intervention and indeed this is what natural resource–rich countries did. In this context, it is worth taking a closer look at Norway's experience.

Until the early 1970s, Norway trailed its neighbors economically. By the turn of the millennium, Norway enjoyed the highest GDP per capita in Scandinavia. In doing this, Norway has been able to draw the full benefits from its oil discovery in 1969 without suffering significantly from the drawbacks of Dutch disease, in contrast to most other resource-rich countries (Stevens, 2003). Norway took early initiatives to immunize itself against Dutch disease. In fact, Norwegian policy-makers contemplated the dangers of the disease long before it was theorized and named. They subsequently learned effectively how to fine-tune the relevant policies. Featured prominently among these policies were investment in education and active promotion of innovation, including efforts to better embed the offshore oil and gas sector in the national innovation system.

A centralized wage formation system and a strong social consensus ensured that wage increases did not outpace the growth of productivity increases in the manufacturing sector. Fiscal discipline and the establishment of a Petroleum Fund abroad to be used domestically only as a counter-cyclical tool, shielded the economy from excessive demand and prevented unwarranted real appreciation of the domestic currency. Spillovers from the energy sector were maximized by domestically accumulating expertise in offshore oil extraction, including support of relevant R&D, instead of relying almost exclusively on foreign specialists. Broader education and innovation policy emphasized maintaining and expanding know-how in industrial and service activities with a view to building new knowledge-based comparative advantages. Several mining intensive countries, such as Chile, Peru, and Colombia, have recently initiated actions along a similar path.

On the Policy Mix

Despite the appeal of creating a toolbox for innovation policy by matching developmental challenges with a specific innovation policy to address it, being too specific presents risks of its own. To a large extent, innovation policies are context specific in that they need to consider the level of economic development, the institutional capacity to implement the policy, the level of sophistication of the economy, and other political economy risks. Thus, defining the best policy mix needs to be done on a case-by-case basis, properly analyzing various dimensions and the mechanisms through which they influence policy.

Lessons from programs in STI in different countries worldwide suggest that it is important to achieve a balance between supply- and demand-side policies. In particular, a clear focus on enhancing business productivity and innovation has to be carried out while maintaining a keen awareness of the fact that efforts to establish a critical mass of scientific and engineering capacity must remain well funded. Policies should target both supply- and demand-side interventions, and strive to coordinate and develop them in close proximity. For instance, the necessary space for curiosity-oriented research should allow for a priority for mission-oriented research, keeping in mind its relevance for business development and finding solutions to social problems.[34] Well-established programs, such as the Small Business Innovation Research program in the United States, have proven that public procurement, if designed in a way that facilitates technology transfer and innovation, can be a powerful tool in focusing research on fields with practical and high economic and social impact.

A major consideration in determining the best policy mix for a given country in a given moment of its economic development relates to designing policy and deciding about public interventions bearing in mind that, even if market failures are endemic, it cannot be taken for granted that the process of addressing them will succeed (Crespi, Fernández-Arias, and Stein, 2014). Positive externalities may fail to materialize or they may be smaller than expected. Public services run the risk of being privately captured. Incursions in vertical innovation or science policy may risk being shaped or implemented in ways akin to old fashioned and distortionary industrial policies. The institutional—bureaucratic, technical, political—capacity to execute a policy instrument that looks optimal on paper may not exist. More generally, rather different policy design and implementation provisions will be required according to how sophisticated the particular economy was to begin with and how far its firms are from the technological frontier. In connection with the distinction made above between types of programs that constitute market interventions and those that produce public goods (see Table 1 on page 28), Table 2 illustrates how some types of policies could be different for national economies operating at different distances from the

[34] By definition, mission-oriented research is associated with the specific problems and circumstances of each country. There is room, however, for some common denominators to be found in issues such as understanding and mitigating the effects of climate change for the whole LAC region, in which case research acquires the form of a regional public good.

technological frontier. The policies in the first row are uniformly less demanding in terms of public sector institutional capacity or private sector sophistication. This, of course, remains a rough approximation of the careful effort that needs to be made in designing appropriate STI policies for each economy. The size of the domestic market and the prospects of foreign markets for each industry, the availability of basic inputs (both human and physical), industry-specific technology trends, global competition, local connectivity conditions, local institutional traditions and regulations, and still other factors need to be weighed to maximize the positive impact of interventions.[35]

Last but not least, other political economy risks are normally worth considering, since innovation policy-making involves several potentially important agency problems that may lead to loss of accountability and undermine policy effectiveness. Given the long time horizons required for innovation and scientific investments to mature, dynamic inconsistency tends to be a major problem facing policy-making in this area.

Table 2. Tailoring Interventions to Specific Country Conditions

Distance from the Technological Frontier	Type: Market Intervention	Type: Public Good
Far	• Innovation funds, technology diffusion programs and institutions • Business incubation • Incentives to adopt ICT • Entrepreneurship education • Business climate reforms	• Enhance engineering education and post-secondary technical programs • Basic technological infrastructure: broadband, standards and quality systems, metrology laboratories • Early stages of competitive scientific research funding
Close	• Public–private financing of seed, angel, and venture capital • Business accelerators • Sector innovation funds • Innovation climate reforms (e.g., technology transfer programs, and initiatives to develop intellectual property rights and regulations)	• Advanced degree scholarships • Advanced talent acquisition strategies • Research institutions in general purpose technologies such as biotechnology, nanotechnology, and ICT

Source: Crespi, Fernández-Arias, and Stein (2014).

[35] An enlightening discussion of how a small economy may need to take into account particular considerations when putting together relevant innovation policies can be found in Jaffe (2013).

In closing, and as an illustration of how the policy mix is conditioned by the type of economy in which it takes place, it is worth considering recent trends in STI policy in advanced economies. Concerns and instruments such as those described below may not be the right fit for the policy mix in LAC economies or they may be beyond reach because of a lack of institutional capacity. However, they express responses to concerns that may arise in developing country contexts and, therefore, may nevertheless be useful:

(i) There is increasing interest in promoting collaboration among the different actors in the system, which is done by introducing designs that stimulate university–industry collaboration, firm–firm collaboration, innovation networks, and technological consortiums. To some extent, policy-makers are showing growing concern in promoting schemes that foster the internalization of spillovers and solving coordination failures.

(ii) There is growing interest in paying more attention to the framework conditions. During earlier stages of STI policy, and not unlike in LAC countries, attention was principally focused on investment in large science projects, which mostly included programs for financing scientific research and providing human capital. Nowadays, it has expanded to include issues such as regulation, competition, and labor market policies.

(iii) There is increasing focus on supporting technologies rather than sectors. Or, if a sector needs to be supported, the justification is provided based on the idea that this sector generates multiple spillovers that expand across economic activities (such is the case of General Purpose Technologies –nano, bio and ICT-). Within each sector and while focusing on these technologies, the interest has gradually moved from the technology supply side to adoption and use across economic sectors.

(iv) There is growing attention on the complementarities among the four different quadrants of interventions and to the policy sequencing among them. For example, the success of an R&D subsidy scheme—a typical program in the bottom left quadrant of Table 1—depends on several of the interventions included in the top left quadrant, which are the framework conditions. Most R&D subsidy programs stimulate private sector demand for advanced human capital and engineers. To succeed, these programs depend on positive supply response from the education system. The effectiveness of R&D subsidies is very likely to depend on the effectiveness of competition policy. Indeed, competition pressures or entry threats force companies to innovate in order to escape competition. So, companies in relatively competitive markets are willing to innovate and thus face the sort of market failures that justify R&D subsidies. On the other hand, in monopolistic markets, R&D subsidies might end up being used by incumbent firms for other purposes or to erect barriers to entry (Aghion, David, and Foray, 2009).

Challenges in LAC

In almost every relevant dimension of the STI landscape, LAC countries differ greatly from more advanced economies.[36] Overall, LAC countries substantially underperform OECD and European Union countries as well as emerging economies such as China, India, and some Central European countries (IDB, 2010). This chapter explores the main aspects of these differences, since most of the issues affect all LAC economies. However, the discussion recognizes that some countries in the region (e.g., Argentina, Brazil, Chile, and Mexico) have begun evolving toward developing a technological profile closer to that of advanced economies. These countries have a collection of policy instruments as well as public and private sector resources that are still not available to other LAC countries.

The low technological intensity of Latin American economies is particularly evident in the list of leading export sectors that represented the largest share of the economic structure in the region over the past 50 years. Box 7 shows a comparison of the evolution of the economic structure of Latin America and that of South Korea. While the economic structure of the South Korean economy began to include more technologically sophisticated industries, and diversified the number and nature of its productive specialization, for the most part, Latin America's economic structure continued to be heavily concentrated in primary exports and low-tech products, with a low technological profile and limited diversification in its economic structure (Crespi, Fernández-Arias, and Stein, 2014).[37] Given the close links between investment in innovation and productivity growth, the slow growth in productivity that characterizes the majority of economies in the LAC region is likely due in part to unresolved and considerable challenges in the STI sector. The following sections discuss the most salient of those challenges.

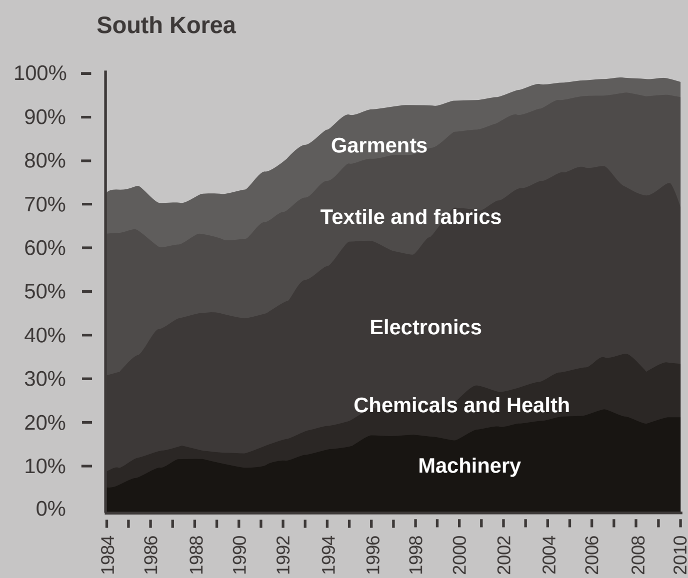
[36] Many of the indicators discussed in this section, and several more of relevance that are not mentioned given space limitations, can be found in the IDB's Statistical Compendium (IDB, 2010a).

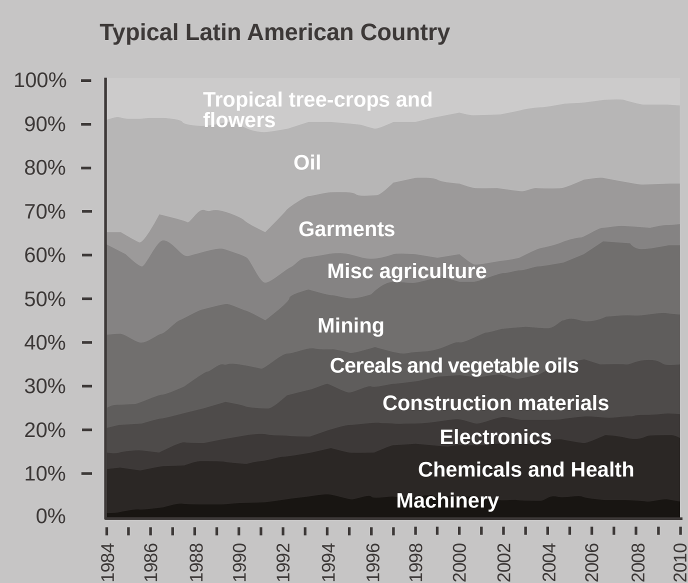
[37] Along a similar line, Katz (2001) and then Cimoli et al. (2006) argue that LAC's economy has even accentuated such concentration in low-tech sectors recently. By analyzing structural changes in Latin America's economic structure between 1970 and 2000 and comparing it to South Korea, Finland, and the United States, these researchers found that growth in South Korea and Finland was associated with a change in the economic structure in favor of knowledge-intensive sectors, which have a role in disseminating technology throughout the 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 these studies.

Box 7. A Low Knowledge-Intensive Economic Structure: Transformation of the Productive Structure of South Korea Compared with LAC

A glance at the change in the technological complexity of exports in South Korea over the past 30 years compared to the typical country in LAC immediately reveals the relative stagnation in the LAC region.

Figure 5. The Complexity of South Korea's Export Baskets Compared with LAC Countries





Sources: Crespi, Fernández-Arias, and Stein (2014) with calculations based on Hausmann et al. (2011).

Low Public and Private Investment in STI

Highlighting the Diversity of Initial Conditions

In the LAC region, innovation systems in the STI sector are at diverse stages of development. Programs and policies aimed at enhancing innovation performance need to be customized to reflect these differences. Thus, countries that have already built substantial capacity in scientific research may need programs that emphasize maintaining that capacity and, above all, approaches that focus on connecting such capabilities with the productive sector. Those economies that do not yet have scientific research capabilities will most likely have to emphasize creating basic science and innovation policies (e.g., mainstreaming peer-reviewed, competition-based selection processes for research and firm innovation projects) and acquiring a minimum critical mass of human capital for innovation. From an institutional point of view, countries with a tradition of science and productive development policy may have to invest primarily in coordination and the overall coherence of their institutional settings. Countries with little institutional precedent may want to invest in a wide variety of instruments that are not demanding in terms of implementation capacity, but allow for a quick learning process in both the public and private sector.[38]

Low Overall Investment in STI

No matter their important differences, most LAC countries underperform other countries with comparable income levels in terms of R&D intensity, which is defined as R&D expenditures as a share of GDP. Underinvestment in STI is a constant across countries in the region. Differences between countries reflect their heterogeneity, but there are matters of degree, with low knowledge intensity clearly the common denominator. Within LAC economies, the gap between R&D intensity and 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 (Pagés, 2010). In contrast, 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; Pagés, 2010; Crespi, Fernández-Arias, and Stein, 2014).

The gap compared with advanced economies is not closing. R&D intensity has grown consistently in advanced economies, establishing a solid base of investment in STI, whereas improvements in LAC countries have on average been modest. In 2011, R&D investment in the region represented 0.78 percent of GDP compared to 0.56 percent in 2001. During the same period, OECD countries increased R&D intensity

[38] Clearly, the path to a knowledge-intensive, highly productive economy is far from unique or linear. For a few outstanding and diverse national experiences see Appendix 2.

from 2.2 percent to 2.4 percent (OECD MSTI, 2014). In addition, in contrast to the rather uniform increased investment in most developed economies, efforts to improve R&D investment in LAC were concentrated in a handful of countries. Over 60 percent of R&D expenditures in the region in 2011 occurred in Brazil, where R&D intensity has reached 1.21 percent of GDP, the highest in LAC. In Brazil, R&D investment is heavily focused on energy and agricultural research (RICYT, 2014). Beyond simple comparisons, available in-depth analyses confirm the innovation shortfall in LAC economies, and low technological intensity cannot exclusively be attributed to a particular kind of economic structure biased in favor of natural resources. On the contrary, empirical evidence suggests that, even correcting for that factor, innovation intensity is low (Maloney and Rodríguez-Clare, 2007; IDB, 2010).[39] LAC's economies are low-tech not only because they are invested for the most part in low-tech industries, but also because, when they invest in any industry, they tend to operate that industry in ways distant from the technological frontier.

Low Private Sector Investment in STI

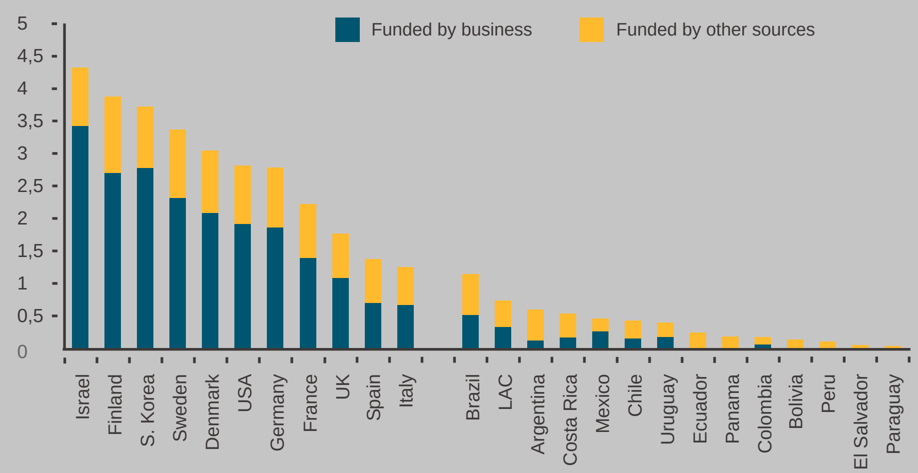
Another characteristic of the LAC region is scant private sector participation in innovation efforts (see Box 8). The financing of R&D continues to be highly concentrated in public institutions (government agencies and universities), averaging roughly 58 percent of the total effort, compared to 35 percent in OECD countries in 2011 (RICYT, 2014; OECD MSTI, 2014). Most of this public investment is spent in public institutions (public research institutes and laboratories), since public programs aimed at subsidizing business and private sector innovation are typically very small.

[39] Analysis focused on using technology in particular sectors confirms this finding. Comparing Chile and Australia in the mining sector, and Chile and Finland in the paper pulp sector, Benavente and Bravo (2009) found that lower R&D investments in Chile accounted for much of the difference in productivity.

Box 8. Low Overall and Private Investment in R&D

In the LAC region, overall investment in R&D (as a proxy for innovation investment) is low compared to advanced OECD economies. Brazil is clearly an outlier, as it accounts for the majority of R&D investment in the region. In the LAC economies that tend to have the lowest R&D investment, the private sector is barely a financial presence in the effort.

Figure 6. Investment in R&D as a Share of GDP and the Proportion Funded by the Business Sector



Notes: Data are from 2010 or the latest available year: 2009 for Bolivia, Costa Rica, and Peru; 2008 for Ecuador and Paraguay. Data for Peru are based on authors' calculations using innovation survey data and data from OECD, 2011.

Sources: OECD (2011) and RICYT (2014).

Firms in LAC have a very different profile in terms of innovation activities compared to firms in advanced economies. A salient characteristic is the low level of expenditure and intensity of effort in R&D. On average, firms' R&D intensity (expressed as a percentage of sales) is below 0.4 percent, considerably lower than 1.61 percent in Europe and 1.89 percent in OECD countries. In all economies, R&D expenditure is highly concentrated in the largest firms. This is also true in LAC, but the disparities between the top 5 percent of firms and the rest is far more acute, clearly suggesting that a particular challenge is not only to raise the overall level of private investment in R&D, but to dedicate special efforts to technology diffusion across the vast majority of SMEs that operate a long distance from the technological frontier. The differences in intensity of innovation investment by firms in LAC and OECD countries are less pronounced given the broad definition of innovation activities adopted in current surveys.[40] In this context, the concentration of innovation effort in LAC firms occurs in innovations that can be considered new for the firm, rather than for the national or global market, and on the purchase of capital goods and equipment related to innovation activities. Expenditures on these items represent between 50 and 80 percent of total expenditures on innovation, while the corresponding share in non-LAC OECD countries varies between 10 percent and 40 percent. In OECD countries, R&D expenditures are frequently the main item of innovation investment.[41]

The View from the Firm

Innovation surveys provide further insight into the way firms finance innovation. Information revealed by firms indicates 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 of business innovation is a minor source of financing for firms in LAC, and tends to be used more intensely by relatively larger firms (Chrisney and Monge-Gonzalez, 2013). According to innovation surveys, less than 6 percent of manufacturing firms in LAC receive public financing for innovation activities, figures that are dwarfed by non-LAC OECD averages. It is clear that direct subsidies and tax incentives put in place by governments across the region in order to encourage business innovation have, albeit effective in their own terms, stopped short of reaching a critical mass of potentially innovative firms (see Box 9). Hence, their economy-wide impact on competiveness and productivity remains modest. Thus, in LAC, failures in the market for knowledge are compounded by government failures in the form of sub-optimal funding of market-correction measures.

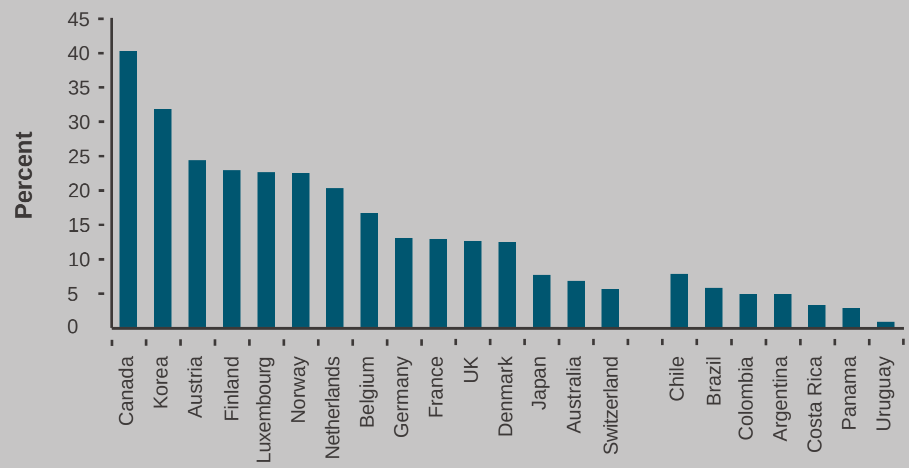
[40] Following the Oslo Manual, innovation activities include the acquisition of technology embodied in capital goods and equipment, hardware, and software; the contracting of R&D services; technology transfer activities such as acquisition of disembodied technology (licensing and buying intellectual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

[41] The combination of low R&D efforts and high investment in technology embedded in machinery could signal problems (IDB, 2010a). 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. This type of innovation activity tends to be a step in the right direction, yet one that generates fewer externalities than innovations that are new to the market, which normally come attached to human capacity building and the creation of valuable intangibles such as intellectual property at the firm level.

Box 9. Public Support for Innovation in Firms

Firms in LAC may have fewer opportunities than firms in the OECD to receive public support for their innovation activities. This suggests that, although the public sector often accounts for the greatest proportion of R&D financing, currently those resources are not reaching firms trying to innovate in LAC.

Figure 7. Proportion of Innovation in Firms Financed by the Public Sector



Notes: Data refer to the manufacturing industry. Indicators are weighted for OECD countries. Data for LAC countries (except Brazil) are provided by researchers and are un-weighted.

Source: IDB, 2010 based on Firm Innovation Surveys for Argentina (1998–2001), Brazil (2005), Chile (2004–2005), Colombia (2003–2004), Costa Rica (2008), Panama (2008), and Uruguay (2005–2006). Data for OECD countries are from OECD (2009c).

Innovation surveys also reveal problems related to market size, suggesting that a lack of integration of the regional market can also be an obstacle to innovation (Egler, Peres, and Rovira, 2014). Lack of economic integration confines many businesses to their domestic—often small—markets. This would imply diseconomies of scale for innovation projects, many of which require relatively large investments upfront and longer time horizons to realize a profit. Reduced mobility for entrepreneurs and incompatible firm-related or intellectual property rights legislation may also be limiting incentives for innovation, although this is an area where considerable research is still required.

A Deficit of Inputs and Weak Framework Conditions

A Shortage of Human Capital for Innovation

The differences with respect to human capital are similarly large. According to the data available, in 2011, on average there were only 1.11 researchers per 1,000 people in the labor force in LAC countries (RICYT, 2014). This number is seven times lower than the OECD average and eight times lower than in the United States (OECD MSTI, 2014). In the LAC region, there are substantially fewer doctoral graduates and doctorates in science and technology per capita than in other parts of the world. For example, on average, there are 3.5 doctorates per 100,000 inhabitants in LAC and only 1.7 of those are in science and engineering, compared with 22.02 doctorates per 100,000 inhabitants in the United States and 18.9 in Spain, with 10.9 doctorates in science and engineering in Spain (RICYT, 2014). Moreover, serious issues persist in terms of integrating female researchers into the academic profession.[42]

Fewer researchers are employed by businesses in LAC countries (on average 24 percent) than in OECD countries, where 59 percent of researchers work in firms (RICYT, 2014; OECD MSTI, 2014). This low participation is explained by a combination of factors, including inadequate mechanisms for market insertion, the orientation of research competencies 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 in 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, thus neglecting the importance of developing research capacity to absorb technology. Consequently, the region's universities produce ideas, researchers, and skills that are largely not used by industry. A combination of this phenomenon with the shortcomings of graduate programs and scarce funding for research has turned brain drain into an issue in LAC, although the severity of it has evolved over time depending on the different circumstances faced by each economy.[43]

[42] In the past few years, there has been a rush of governmental activity across the region to address the shortage of highly skilled human capital. Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, and El Salvador have launched scholarship programs of unprecedented funding and coverage, mostly focused on sciences and engineering. Other countries in LAC are rapidly following suit.

[43] Flight of highly skilled human capital key for innovation activities is known to be a particularly serious challenge in the Caribbean region (Docquier and Schiff, 2008). For recent LAC-wide reviews of the issue see Lozano-Ascencio and Gandini (2012) and Martínez, Cano, and Soffia (2014).

Progress in Scientific Production but Still Lagging in Patenting

Scientific performance in LAC countries continues to lag developed countries. There are fewer than 200 scientific publications per million inhabitants in LAC, as opposed to over 1,500 in OECD economies (calculations based on SCImago, 2014). However, the picture is somewhat more nuanced, particularly considering that, in 2012, Brazil (13), Mexico (31), Argentina (40), Chile (46), and Colombia (49) ranked among the top 50 out of 225 countries in terms of scientific publications (SCImago, 2014).[44] On a normalized scale of 170 countries, between the mid-1990s and the mid-2000s, the region improved its position slightly. The rate of growth of publications from Latin America tripled between the late 1990s and the mid-2010s, thus LAC has outpaced some other regions and consequently reduced the gap (IDB, 2010). The nature of research in LAC economies is also different from that in OECD countries. There is less applied research, notably in engineering and technology. The share of researchers working in those fields as a percentage of total researchers is between 10 and 30 percent (RICYT, 2014), whereas in countries such as Singapore, Japan, and South Korea this figure is 60 percent (UNSECO, 2014; IDB, 2010a).

Yet, even if becoming a leading source of new knowledge in a particular scientific field or industry is beyond reach for a given LAC country, the need to adapt processes, machinery, and products, and to acquire skills to customize or use them, is rapidly becoming an innovation intensive activity. A key question has become whether a given developing economy has put in place the basic conditions—a minimum of scientific skills, trained labor force, advanced equipment, communications infrastructure, and business and governmental sophistication—to identify, obtain, adapt, and use existing knowledge to accelerate technological change. The answer tends to be negative in most LAC economies (RAND Corporation, 2007). The challenge seems to be sustaining the effort in leading countries, while spreading a minimum of scientific capability across all economies in the region. Basic scientific capabilities will be required to keep apace of the multiple applications of science in fields of critical economic importance such as energy, environmental protection, transportation, telecommunications, and agriculture. In this regard, R&D should be seen as both a source of original ideas and a source of absorptive capacities to search for and adapt existing ideas to local conditions.[45]

[44] These rankings are very sensitive to weighting the data by either population or GDP. For example, Brazil accounts for over 50 percent of the publications in the region, yet if its publications are weighted by population, its rank drops to 76 out of 206 countries. Chile, with roughly 8 percent of the publications in the region, becomes the region's frontrunner at 57 out of 206 countries when rankings are weighted by population. When rankings are weighted by GDP, as they are by the World Intellectual Property Rights Organization (WIPO) Global Innovation Index, the rankings change to Chile (52), Brazil (59), Argentina (77), Colombia (97), and Mexico (100).

[45] Even more, given the strong natural resource base of the productive structure of many LAC countries and the specificities this generates, some degree of local R&D is necessary to exploit comparative advantages more efficiently.

Despite such achievements in scientific performance, the technological performance of the LAC economies has remained extremely poor. The region's ranking in number of patents has fallen to 5.4 from 6.3 on a scale of 0–10 in about a decade (IDB, 2010). Between 1 and 5 of 100 firms in any given LAC economy hold a patent, compared to between 15 and 30 in European countries. When looking at trends in patenting and trademarks, it is clear that most of the world is moving toward newer technological fields and, generally speaking, the LAC region is not increasing its patenting productivity at the same pace as its scientific productivity. A particularly serious cause for concern is that domestic firms in LAC seem to have little use for the patent system, as evidenced by the fact that foreign companies request several times the number of patents in LAC markets than national, resident firms. This points to another source of government failure in LAC, one that has to do with inadequacies in allocation of property rights that prevents firms from turning their ideas into value, a key component of a modern knowledge economy.[46,47]

A Weak Innovation Climate

The progress observed in terms of scientific capabilities (as evidenced by gains in scientific productivity) has not necessarily translated into proportional improvements in commercializing ideas or other innovation indicators, such as patents.[48] This suggests there are still significant weaknesses in the linkages between the actors in the innovation system. Thus, even if increasing scientific productivity reflects a relative strengthening of the university or academic pillar of the system, new knowledge and technical capabilities remain boxed inside laboratories and research centers, since collaboration between the universities and industry remains weak. New knowledge inputs are not necessarily translated into innovations and productivity gains in firms. Innovation surveys show that LAC firms most often establish technological cooperation agreements with clients and suppliers. Universities and institutes of technology tend to be less important as partners for innovation activities (Pagés, 2010; Anlló and Suárez, 2009).[49]

[46] In 2013, the top five technological categories of Patent Applications Filed under the Patent Cooperation Treaty were (1) electrical machinery, apparatus, and energy; (2) digital communication; (3) computer technology; (4) measurement; and (5) medical technology. In 2012, the patents granted in those categories in the LAC region were less than 1 percent of the number of patents granted to high-income economies in all five categories. Of the five technology categories, in the LAC region, the most patents were granted in medical technology, with 341 patents awarded in 2012, whereas only 44 patents were awarded in digital communication (WIPO, 2014). In LAC, the only fields showing some upward trends in terms of patenting are those directly related to natural resources, such as mining and agriculture. Both large private companies and public research and technology entities (e.g., Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Instituto Nacional de Tecnología Agropecuaria (INTA), Instituto de Investigaciones Agropecuarias (INIA)) are behind this trend.

[47] In terms of trademarks, in 2013, the top five applications by trademark class using the Madrid System were (1) computers and electronics; (2) services for businesses; (3) technological services; (4) clothing, footwear, and headgear; and (5) pharmaceuticals and medical preparations. In 2012, LAC applications in all five classes were less than 1 percent of those by high-income countries. The class in the top five with the most trademark applications from the LAC region was technological services, with 147 applications compared to over 100,000 from the high-income countries (WIPO, accessed July, 2014).

[48] The progress has also not translated into an improvement in rankings along a composite indicator of innovation that accounts for market and business sophistication, high- and medium-tech exports, and other innovation output and input related indicators.

The importance of an innovation climate has led several countries in LAC to develop explicit mechanisms of cross-sector coordination in innovation policy, such as industry roundtables and innovation workshops on shared research agendas. These have been introduced deliberately to improve coordination and encourage pooling of resources and sharing of priorities among the key actors of the innovation system (Avalos, 2002). The same can be said for a few countries that have encouraged the institutionalization of mechanisms and incentives for university–business links. Most of this, however, is still tentative compared with the magnitude of the challenge (Arza, 2010; Cimoli, 2010).

A particularly important enhancement of the innovation climate that, given its complexity, cannot be taken for granted is the financial system, which must be sophisticated enough to handle the needs of technology-based, rapid-growth new companies. In Latin America, venture capital is orders of magnitude below developed economies and below China and India (Stein and Wagner, 2013). In addition, well understood and practiced venture capital goes far beyond providing financing. It involves value creation by involving experienced investors and managers in the growth and eventual success of a start-up.[50] In a positive development, the venture capital market has been growing rapidly since the last decade. In Latin America, Brazil, Mexico, and Chile have accumulated experience in venture capital, and Uruguay is well advanced in putting together a complete cycle of venture finance, including seed, angel, and venture investing. Other economies are moving forward quickly. Valuable lessons have been learned, both regionally and globally, that provide a solid platform for accelerated catching up in this area (Lerner et al., 2013).

A good innovation climate also goes beyond having an adequate venture capital cycle.[51] Given the strong interactions between innovation and competition,[52] and despite the progress made in several LAC countries to improve competition regulation, there is still a lack of coordination between competition and innovation policies.[53]

[49] Several countries in the region have developed programs specifically to improve the links between universities and firms, in some cases through additional incentives for projects contemplating collaboration (Fund for Innovation and Technology (FINCYT) in Peru) and sometimes by supporting the creation and functioning of specialized offices in universities and other research institutions charged with cultivating links with private businesses (Ministry of Science, Technology, and Productive Innovation (MINCYT), Argentina). Although these programs have received favorable evidence-based assessments, innovation surveys do not seem to register a clear impact among firms at the national level (Navarro and Vargas, forthcoming), most likely due to their relatively small scale.

[50] See Hellman and Puri (2002) regarding venture capital.

[51] There are indications that embryonic attempts at setting up venture capital markets in LAC countries have found an almost impossible hurdle in weak deal flow, meaning there are few ideas that are worth supporting (Garcia-Robles, 2011).

[52] An in-depth exploration of the relationship between competition and innovation is beyond the scope of this book. Existing literature shows that this relationship is endogenous (Jaffe, 2000; Hall and Harhoff, 2012). Specifically, according to Aghion et al. (2005), the relationship is an inverted-U, where competition encourages innovation in firms that operate at similar technological levels and discourages innovation in laggard firms, all caused by the difference between the firm's pre- and post-innovation rents. For further analysis see Hart (1980); Schmidt (1997); Aghion et al. (2001); Vives (2008); Schmutzler (2009, 2013); Nickell (1996); Blundell, Griffith, and Reenen (1999); Aghion et al. (2005); Aghion and Griffith (2006); Aghion et al. (2014).

Basic components of the national innovation system that advanced economies take for granted, such as quality certification, metrology, and a variety of technological services to industry, are weak or absent in many LAC countries. Intellectual property rights are often less than adequately regulated to encourage innovation. Intangible assets, such as personal relationships and trust, business and knowledge networks, global connections, entrepreneurial culture, legal and management awareness, and savvy, and other forms of know-how that consist primarily of tacit knowledge, are increasingly being identified as important innovation ingredients that can help make an innovation system function better. From the standpoint of a systemic notion of the innovation system, knowledge ends up being adapted, created, or traded in the context of interactions that resemble a market for ideas. Such a market (e.g., the market for patents or designs) involves inventors and firms willing or in need to try new approaches to processes, products, and business models and a variety of intermediate agents, which are in extremely short supply in LAC. An outstanding exception to this generalization is the city of Medellin, which is becoming a leading innovative city through a variety of novel programs that together are an attempt to tackle the systemic deficiencies of the innovation environment as a whole, most of them around Ruta N (De Leon, forthcoming). Other localities are starting to work along the same lines. The novelty of these programs requires further research and impact evaluation.

The Challenge of Weak Institutional Capacity

The collection of policy tools available to LAC countries promoting innovation is not very different from that available to governments in advanced economies. However, the similarities conceal some significant differences, the most salient of them being wide gaps in institutional development. Advanced economies long ago established an institutional framework that has considerable built-in policy setting and management capacity. The key elements of institutional best practice are consolidated, particularly strong public–private dialogue, strong intra-government coordination, and clear distinction between strategy setting, policy-making, and policy implementation agencies and instances (Rivas [Gonzalo], 2010). Yet such a framework is still in the early stages of development in most LAC countries.[54] Lack of well-developed institutions creates policy risks related to a deficit of dynamic consistency, poor coordination, and capture. Over the last decade, reforms in several LAC countries suggest a keen awareness at the top policy-making levels of the need

[53] Most of the decisions regarding innovation policy in LAC are made without seriously considering the industrial organization of the sectors the innovation policy is supposed to impact, which is likely to have a detrimental effect on their impacts (Aghion, David, and Foray, 2009; Hsieh and Klenow, 2009).

[54] One after the other, comprehensive assessments of LAC's innovation systems highlight the conclusion that enhancing the institutional setting responsible for STI policy must be considered a top priority. For examples, see OECD (2007) for Chile; OECD (2009a) for Mexico; OECD (2014) for Colombia; UNCTAD (2012) for the Dominican Republic; OECD (2011) and UNCTAD (2011b) for Peru; Guaipatin and Schwartz (2014) for Ecuador; UNCTAD (2011a) for El Salvador; and Guinet (2014) for Trinidad and Tobago.

to advance institutional STI policy. Success stories of institution building exist, yet in most countries the institutional landscape remains in flux, still removed from an efficient and stable framework (Rivas and Rovira, 2014).[55]

More specifically, and beyond the larger institutional and governance arrangements of innovation policy, LAC countries face important challenges in terms of institutional capacity. The following are among the pending challenges:

(i) The need to sustain policies over the long term. The effectiveness of some innovation policies is only seen in the medium and long run, but it takes time to build a critical mass of human resources in science and technology and R&D capabilities in private firms.

(ii) The need to strengthen institutional capacity to formulate, monitor, and evaluate innovation policies. Evaluation and oversight are weak in most LAC countries and should become a central part of the new culture of innovation policy practice.

(iii) The need to develop information infrastructure to monitor STI policies and programs, and build it into planning and—ideally multiannual—budgets.[56]

A New Generation of Challenges

The Particular Challenges of Adopting and Using ICT

LAC countries' access to new ICT has been late and partial, as illustrated by all available indicators, such as the number of personal computers, internet access, and access to broadband.[57] This lag is particularly important when analyzing the effects of innovation on productivity, since ICT is a general purpose technology that has a cross-sectional impact on all economic sectors. Advanced uses of ICT have not spread throughout the vast majority of SMEs in LAC, and two specific issues are worth highlighting. First, severely underdeveloped broadband infrastructure and

[55] The transformation of some countries into leading knowledge economies has in all cases been accompanied by substantial processes of institution building in STI policy. See Appendix 2 for accounts of the experiences of Finland, Israel, and South Korea.

[56] According to a comparative study of 11 institutions managing STI policy in Latin America (Ventura, 2010), agencies are weak in management and operations. Technological modernization is needed, notably information systems infrastructure and its adequate use, as well as policy delivery and monitoring. Another key issue is the limitations in recruiting, developing, and managing talent, which typically leads to a serious gap in agency capacities vis-à-vis their counterparts in the private sector and sometimes in the science sector, with negative effects on effective implementation. In countries where public resources have dramatically increased budgets, agency organization, internal processes, and delegation have not always been revamped, leading to serious bottlenecks in budget execution.

[57] Several specific factors hamper the spread of broadband use and are worth mentioning: lack of coverage, high prices, low quality, and lack of skills among individuals, firms, and public agencies to use related services.

regulation are major constraints to productivity growth in the region, particularly in the service sector, which critically depends on ICT for innovation. Second, a well-developed software industry is necessary for advanced uses of ICT to reach a critical mass in any economy. With the exception of a few success stories in a limited number of digital hubs in Argentina, Brazil, Mexico, Uruguay, and a few others, the software industry has not reached the necessary level of development in the LAC region.

Only one ICT adoption indicator is excellent in LAC: the market penetration of cell phones, which has reached saturation levels among the adult population across the region. This sector has benefited from accelerated technological innovation and cost reductions in the industry worldwide, and more advanced and private-sector friendly regulation, but marketing and business model innovations, such as pre-paid phone time, are widely considered to have made the difference in the rapid rate of adoption. Even if success in access to critical mobile communication technology so far has failed to translate to other ICT, the growing importance of mobile services and applications and their economic impact on almost every sector of the economy provide a key platform for innovation in the region.

Some exceptions among large firms that have followed good overall approaches to adopting ICT show that it is possible for LAC countries to exploit the potential of ICT (Alves de Mendonça, 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 end result is that LAC economies have largely been deprived of one of the main engines of productivity growth in the rest of the world, a deficit that is particularly serious in the service sector, which exhibits the most serious productivity deficit. 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.

Policy responses have also created important limitations. Several countries, Colombia being a particularly recent and outstanding model, have put together ambitious national digital agendas. For the most part, however, ICT policies show a strong bias toward developing e-government, particularly in financial management, procurement, and management of tax and revenue systems. This bias is at the expense of a necessary focus on programs that enhance the capacities of the private sector to adopt and use ICT technologies, such as improving the supply of specialized human capital for the ICT industry and ICT-based business services, government assistance to SMEs incorporating advanced ICT applications into business, investments to improve the population's level of digital literacy, and investments in broadband infrastructure, so that other policies can bear fruit.

Making Innovation Relevant for Social Issues

In LAC, beyond competitiveness and productivity lies a crowded and compelling need to address deficits in social inclusion of people with disabilities, poverty reduction, access to health care and education, gender equality, re-integration of displaced communities, and environmental protection. Recent diffusion of open innovation platforms has renewed interest among policy-makers in the potential to apply design thinking, crowdsourcing, and digital media to accelerate the rate at which social problems are identified and high concept solutions are found and applied. In the meantime, it is also necessary to enlarge the pool of potential participants to both identify and resolve the challenges. Several countries have already experimented with internet- or mobile-based platforms that prompt information from isolated or excluded populations, allowing these populations to prioritize the problems identified. Online platforms then publicize the list of priority problems to research centers, consulting and technology companies, and universities, creating a competition for the best, least expensive, and most sustainable solutions to be designed and implemented. Along with governments, many private firms are innovating to increase social inclusion and address social costs. Social innovation platforms have been used to develop business models that support the base of the pyramid populations, while social investment bonds are expanding private solutions to providing social goods.[58] However, a considerable challenge remains in mainstreaming social innovation in the traditional practices of ministries, agencies, and the private sector so that it fulfils its potential.

Policy-Making in STI and New Challenges

In LAC there has been a low level of investment in STI over the past half century. This period was distinctive worldwide for innovation and technology revolutions, and for the emergence of leap-frogging economies based precisely on unprecedented investments in STI. When traditionally low levels of investment are contrasted with the very high rates of return consistently found when analyzed (see the prior section *Innovation, Scientific and Technological Development and Economic Growth*), one conclusion is that the very modest flow of resources must have causes deeply rooted in the policy-making process for STI across the region.[59] Another conclusion is that a correction is overdue, and there are already signs that indicate the correction is starting.

[58] For example, efforts by the Family Compensation Fund of Antioquia (Caja de Compensación Familiar de Antioquia, COMFAMA) in Colombia, a private non-profit entity funded by public and private sector employees, suggests that public–private partnerships are a means of developing practical, business-led social innovation.

[59] If a low level of investment (presumably sub-optimal) persists in an economy in the long run, and it is not fully attributable to the economic structure of that economy (as in most if not all LAC countries) an explanation might be found in the policy-making process.

Recent developments in some LAC countries suggest that the trend of underinvesting in STI is beginning to reverse. Natural resource royalties in countries such as Chile, Colombia, and Peru have recently been channeled directly to R&D, regional innovation systems, massive scholarship programs for scientists and engineering, or building research capabilities in universities and technology parks.[60] These developments have made available unprecedented levels of funding for STI activities, while creating institutional and policy challenges, in particular how to efficiently use the additional resources. The new level of funding has renewed the focus on the deficit of institutional capabilities to deal with rapidly growing resources, as well as on the very nature of the policy-making process in STI (Aninat et al., 2010; Navarro, 2014). The new and augmented flows of resources have been accompanied by two new influential actors in policy-making: subnational governments and the private sector, actors that in turn have the potential to engage in direct interaction.

For a long time, only two dominant actors counted in STI policy-making in LAC: the government (primarily the finance and planning ministries, which have considerable control over budget allocations and spending priorities) and the scientific community. These actors wielded veto power in policy matters for STI policy.[61] Yet they were normally at odds in terms of their understanding of the key goal of STI policy—contribution to economic development vs. contribution to knowledge—and time horizon—short-term vs. long-term results. Economic authorities typically feel that, once they allocate resources they will lose control of the details of their use and, in particular, will be unable to align their use for the benefit of economic and development goals. Scientists, in turn, lack the authority or political power to impose an increase in public funding, but they retain their autonomy in managing research and rejecting as intrusion any intervention not directly motivated by principles of academic excellence. In the absence of a well-developed institutional framework that limits the damaging effects of this kind of policy-making process, the result has been a consistently low level of investment in STI—well below what would be considered socially efficient levels. Traditionally, for the most part, the private sector has lacked the inclination to become a part of the process.

[60] In Colombia, according to Articles 360 and 361 of the Constitution, 10 percent of revenues of theGeneral Royalties System Fund will be directed to STI. In Peru, according to Article 6.2 of Law No. 27506, 25 percent of the Canon funds (royalties from exploiting different natural resources) must be allocated to the regional government where the natural resource is exploited, of which 20 percent are exclusively for public investment in universities for scientific and technological research that promotes regional development. Also, through the Law No. 28258, Law of Mining Royalties, it was established that 5 percent of these funds should be for universities. In Chile, Law No. 20,026 establishes a specific tax on mining activity, which was created to allocate 20 percent of its revenue to innovation funds. Despite the above, because of the existence of the principle of No Allocation of Taxes, Article 19 No. 20 of the Constitution, which states that all taxes, regardless of their nature, must enter the equity of the country and cannot be channeled to a specific destination, it is impossible to determine if the budget for innovation comes from the specific tax on mining.

[61] Three key characteristics of the interaction of these two actors that are critical—asymmetries of information and agency problems—undermine the ability of both to work together constructively and trust each other. Their preferences are, for the most part, not aligned, and their conflicts are not mediated or nuanced by the presence of the private business sector as a major player, which constitutes a stark contrast with the political economy of STI in advanced economies.

Very recently, however, the private sector has become more vocal and proactive in demanding that innovation becomes a top governmental priority,[62] and national governments have paid attention. In addition, there are some significant voices at the subnational levels of government. Given that the exploitation of minerals that generates the royalties being channeled to innovation are usually concentrated in a number of states or provinces, the authorities of these regions are being very proactive in demanding participation in the decision-making process of innovation policy. A good number of cities in LAC are, at the same time, pledging to become innovation hubs and starting to invest heavily in technology and innovation.[63]

The entry of the private sector and subnational governments into the policy-making process may have already modified the traditional—and poor—equilibrium that produced decades of underinvestment in innovation in the region, and that would be enough to label it the most important development in STI policy in recent years. The change brings considerable challenges, however:

(i) How to ensure that decentralized decision-making will not undermine key national programs and initiatives that necessarily require a large scale.

(ii) How to develop institutional capabilities in the subnational levels of government akin to their new weight and participation in policy-making.

(iii) How to find ways to channel the private sector's increased activism in ways that will be constructive to policy-making, mitigate the risk of capture, and minimize demand for distortionary policies.

[62] Witness the work of the Private Competitiveness Council and the Connect Bogota initiative in Colombia, the work of the Red Enlaces that links business people focused on innovation, the forceful participation of private sector representatives in preparing the competitiveness agenda in Peru, the work of the Competitiveness and Innovation Council in Chile, and the role of the Economic Development Board and the Innovation and Competitiveness Council in Trinidad and Tobago.

[63] A very partial list includes Recife, Belo Horizonte, Buenos Aires, Guadalajara, Monterrey, Medellin, Montevideo, and Santiago.

The IDB's Experience in Supporting STI

The IDB has been supporting STI in the LAC region since 1962. The longevity of both financial and technical support demonstrates the commitment on the part of the Bank and a growing number of countries in the region to strengthening the sector. This commitment stems from mutual recognition of the critical role that STI plays in the ability to increase productivity and compete in global markets.

Approaches to support STI have changed over the years. The evolution reflects learning on the part of the IDB and the region. Lending programs have transitioned from supply-driven to demand-driven to a systemic approach to the sector. However, programs are always tailored to the particular needs of a country, and supply-oriented approaches are still regarded as critically important since the region's overall performance still lags, particularly, albeit not solely, when the sector's development is still in its infancy.

Assessing the Impact of IDB Support

The IDB's 1994 board of directors solicited an ex-post evaluation of the Bank's science and technology projects from its Office of Evaluation and Oversight (OVE). The report, which was finalized in 1998, concluded that the programs reviewed played a significant role in strengthening national capacity in science and technology in the borrowing countries. The report pointed out that, especially in early periods (from 1962 to 1981), only three countries requested loans in science and technology—Argentina, Brazil, and Mexico—and those were the countries that already had some STI infrastructure and capacity. The situation has changed significantly. Even if some of the largest economies in the region still demand STI operations, the demand has spread to almost all borrowing countries, although Bank programs are tailored to the different baselines, local conditions, levels of economic development, and institutional strength of STI policies. The report also highlighted the IDB's transition toward the contemporary systems approach of focusing support on the network of institutions, both public and private, in National Innovation Systems. This general orientation continues today.

Since the report was produced in 1998, OVE has evaluated the impact of a number of innovation programs. See Table 3 for information about six of those evaluations. The results of these impact evaluations and other impact evaluations carried out by the IDB and other leading researchers[64] have been in line with international literature. Program incentives for business innovation have been shown to have positive results in increasing a firm's ability to invest in innovation, little evidence of crowding out private sector investment and, in the most recent studies, evidence of an impact on productivity levels and positive spillovers for firms that did not participate directly in the programs. Currently, researchers inside the Bank (the Competitiveness and Innovation Division and the Office of Strategic Planning and Development Effectiveness) and in other organizations are making use of newly available and much improved data to extend the time horizon of the analysis. So far, these results have demonstrated that the innovation programs have had a positive and significant impact on labor productivity. Furthermore, preliminary evidence suggests programs that encourage business–university linkages typically have the greatest impact (Crespi, 2012).

Table 3. OVE Impact Evaluations of IDB's STI Programs

Type

Country / project	Type of intervention	Authors (year of pub.)
Argentina / FONTAR-TMP1	Subsidized loan	Chudnovsky et al. (2006)
Brazil / ADTN	Subsidized loan	De Negri, Borges Lemos, and De Negri (2006a)
Brazil / FNDCT	Parallel subsidies	De Negri, Borges Lemos, and De Negri (2006b)
Chile / FONTEC	Parallel subsidies	Benavente, Crespi, and Maffioli (2007)
Panama / FOMOTEC	Parallel subsidies	López et al. (2010)
Argentina / FONTAR-TMP1 and FONTAR-ANR; Brazil / ADTN and FNDCT; Chile / FONTEC; Panama / FOMOTEC	Evaluated for R&D input additionality, behavioral additionality, increases in innovative output, and improvements in performance	Hall and Maffioli (2007)

Notes: Many other STI impact evaluations have been carried out in the region. See Corbacho (2012) for additional findings and details. This table highlights the work carried out by the OVE in conjunction with the listed authors in contributing to knowledge and program design in the area of STI. FONTEC is the National Fund for Technological and Productive Development in Chile (Fondo Nacional de Desarrollo Tecnológico y Productivo).

Source: Crespi (2012).

[64] For a detailed summary of the results, please see Crespi (2012).

Impact evaluations of business innovation support programs are fraught with challenges in terms of identifying (i) counterfactual groups; (ii) indirect and direct beneficiaries; and (iii) externalities. This clearly implies that, in an era using the systems approach to support STI, there is an ongoing effort to sharpen the methodological approaches to better capture the costs and benefits of the typical programs. In parallel, since the range of public interventions has been expanding, new approaches and methodologies need to be devised to assess the impact of policies such as upgrading value chains, clusters, entrepreneurship development, institutional strengthening, and innovation climate. Doing so is clearly a major pursuit in the Bank's knowledge agenda in the sector.

In 2011, in response to some of the challenges posed by evaluating the effectiveness of interventions in the sector, the IDB produced a set of evaluation guidelines (Crespi et al., 2011). The guidelines provide technical advice on how to assess the effectiveness of STI programs. The toolkit addresses specific challenges in evaluating STI programs, such as assessing the intervention logic, and providing methodological choices and problem solving tips based on previously encountered challenges with data and/or analysis. The publication devotes substantial sections to discussions about data (data sources, quality issues, and data collection strategies, as well as the application of quantitative methods such as experimental and quasi-experimental design). Developing similar products is fundamental to the IDB's growth in capabilities in the sector and for its position as a technical assistance provider to countries in this area.

Non-sovereign guaranteed operations have also played an important role in promoting STI in LAC through a range of activities, including support for innovation finance through equity investments, ICT infrastructure, social innovation, and productive integration projects. Since 2001, non-sovereign guaranteed operations have approved 396 operations worth US$1.2 billion for STI-related activities (see Appendix 1). The IDB's Multilateral Investment Fund has been a catalyst in developing the financial eco-system needed to support firm innovation. OVE found that 85 percent of all projects financed by this Fund introduced innovation, and 22 percent introduced innovations that were replicated in other areas of the economy (OVE, 2013).

The IDB's Strengths and Comparative Advantages in STI

With a portfolio of 31 lending programs and US$1.3 billion, and as an active partner in the majority of the borrowing countries with two-thirds of current active loans operating in small and vulnerable countries[65] C and D countries, the IDB has built the largest operational footprint of any international financial institution operating in STI in LAC (see Appendix 1). Today, the IDB can count on strong name recognition, excellent rapport with national counterparts, and a reputation as a source of state-of-the-art technical advice. In STI, the IDB has been strengthening collaboration with other international institutions in the field, such as the World Bank, OECD, and ECLAC, to facilitate cooperation rather than competition and best serve the needs of the countries in the region. As a consequence, demand for IDB support for STI projects is growing, and the complexity and sophistication of the interventions contemplated in new operations is increasing.

The high regard for the IDB in STI is a result of the proven effectiveness of the policy instruments typically included in the Bank's operations (such as innovation funds), and the fact that several success stories in capacity building are closely associated with the Bank's support and funding.[66] Since most of the operations in STI are primarily concerned with private sector development, many firms, SMEs in particular, know of the Bank as a supportive source of funding or technical assistance through public innovation and competitive programs. In particular, private sector operations and the Multilateral Investment Fund have led the way in key areas, such as venture capital development, further contributing to the Bank's recognition among businesses. Because the Bank is willing to be a partner in the medium to long term, it can be a source of dynamic consistency as authorities or budgets change from one year to the next in an area of public policy that is particularly sensitive to short-term volatility.[67]

This stock of experiential know-how has been recognized by governments thanks to the IDB's investments in impact evaluation and policy research, which have played a critical role in presenting evidence of what works and what does not. Furthermore, the IDB has acted as a catalyst, guiding policy interventions that have found resonance in the problems and concerns of the counterparts in the governments. These include pioneering work in social innovation and mobile services, original applied research on service innovation, natural resource-based innovation, technological diffusion, and entrepreneurship.

The IDB has taken on a leadership role in the policy research agenda at the international level, as evidenced by the number and quality of its publications.[68] Major contributions, such as the *Development in the Americas* publications on productivity (Pagés, 2010), information technology (Chong, 2011), and most recently, productive development policy (Crespi, Fernández-Arias, and Stein, 2014) include detailed analytical consideration of the role of innovation and innovation policy. Often, Bank projects incorporate financing of data gathering (innovation and enterprise surveys) in

[65] According to the IDB this classification applies to: Bahamas, Barbados, Belize, Bolivia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Suriname, Trinidad and Tobago and Uruguay.

[66] This is one of the Bank's particularly important strengths in the current environment of growing funding being channeled to STI in a number of countries in LAC. Normally the budget assignments run ahead of the indispensable institutional capability to use them well, doubling the already critical importance of institutional strengthening.

[67] See Chapter 10 of *Observario Colombiano de Ciencia y Tecnología* (2013) for more on the role of the Bank as a factor contributing substantially to institutional development and policy-making in STI over time in Colombia. The IDB's work in this case has been analyzed and recognized.

[68] A search of the IDB's repository of institutional knowledge yields 102 publications by the Competitiveness and Innovation Division, which focuses on STI policy.

cooperation with innovation and competitiveness agencies or national statistical agencies. This results in useful new knowledge and institutional strengthening in the counterparts. At the request of the governments, several projects are investing directly in program evaluation beyond the minimum requirements of regular mid-term or final evaluation of Bank projects. In addition, the IDB has also been instrumental in putting together comprehensive innovation and private sector assessments that have played an important role in shaping policy and institutional reforms in several countries.

The Bank, in close partnership with Canadian and UK development agencies, has managed the Compete Caribbean program, which has become an effective lever for introducing and strengthening innovation across the Caribbean. Pioneering work on competitiveness, productivity, the current state and challenges of the private sector, and innovation in Caribbean nations has been advanced within the framework of this program.[69] The Bank's leadership in productive development policies in the region is recognized both in terms of supporting institutional development in competitiveness and innovation (e.g., through a series of operations supporting policy analysis and coordination in innovation and competitiveness councils) and in interfacing with private companies through a system of competitive grants for innovative firms.[70]

The Bank has built a strong track record in supporting internationalization of services, an area in which ICT is the key enabling technology. A combination of lending, research, and technical assistance has resulted in a mutually reinforcing complement to the growing involvement of the Bank in innovation in the service sector. The IDB has also built an innovation engine of its own. The I-Lab (see Box 10) has been a successful vehicle for piloting new ideas in an open innovation framework. It has produced tangible results in social innovation and mobile services, which are both highly valued by the Bank's clients. Knowledge and design created by the I-Lab has been scaled and incorporated in components of lending operations as well as technical cooperation programs. Also, its work has been conducted in a way that has produced substantive evidence about the impact of the programs, thus contributing to the IDB's knowledge agenda in the STI sector.[71]

[69] This reserve of knowledge includes private sector assessments for each Caribbean economy, the first national innovation survey for each Caribbean nation, a study of regional value chains, a review of the gap in innovation and technology affecting the region in the tourism sector, an analysis of the Caribbean entrepreneurial diaspora, a mapping of industrial clusters across the Caribbean (Rabellotti, forthcoming) and the first comprehensive innovation policy review of a Caribbean country's innovation system (Trinidad and Tobago).

[70] In launching this type of funding for innovation projects in firms, Compete Caribbean can be seen as replicating, at the regional level, the successful support for business innovation through competitive innovation funds that the Bank usually channels at the national level in larger economies.

[71] The I-Lab has also had spillover effects by applying open innovation platforms that have promoted innovation processes within the IDB itself. The early success of this line of work points to the potential of further pursuing this path. A full exploration of this idea lies beyond the scope of this document.

Box 10. Social Innovation in the IDB: The Innovation Lab (I-Lab)

In recent years, innovation and technology have seen unprecedented growth, touching people's lives more than ever before. However, these advances have not been equally reflected in bettering the lives of socially excluded groups. This is where social innovation and the work of the I-Lab come in: to find cost-effective, long-lasting solutions to social problems.

The I-Lab is an initiative of the Competitiveness and Innovation Division of the IDB for developing social innovations. The I-Lab is a platform for sharing challenges and exchanging ideas and solutions on various development issues in LAC. Through the I-Lab networks, problems in the region are converted into high-impact innovations. Through new technologies, the I-Lab has contributed to identifying the most important problems experienced by people with disabilities and the most innovative solutions.

The I-Lab approach is based on three principles: (i) we cannot assume what the problems faced by socially excluded groups are; (ii) the problems usually are complex and multifaceted so developing a solution requires interdisciplinary collaboration; and (iii) using technology offers a fresh approach to identifying and resolving old problems.

Based on these principles, in 2008, the I-Lab launched its first call for proposals. The objective of this call was to include people with disabilities. The call started with a Problem Contest that was open for six weeks. The three most voted on problems received over 150,000 votes from all over the region. The website (http://www.bidinnovacion.org/) received 1.6 million hits in three months, with 49 problems having been presented from 58 different countries. The leading problem received 61,160 votes.

The initiative continued with a Solutions Contest for the five problems with the most votes, and over 200 project proposals were submitted. A panel of experts in different disciplines analyzed the proposals and selected the best projects. Finally, funds were provided to innovators, businesses, and universities, several of them linked to top technology and research centers around the world that would be able to develop solutions to the selected problems.

The opportunities to solve social problems through innovation are vast. For examples of the I-Lab projects, refer to the IDB's *Social Innovation* publication (IDB, 2013) and the I-Lab's website (http://www.bidinnovacion.org/).

Another source of the IDB's strength in the STI sector is its long-standing and continuously running Regional Policy Dialogue in competitiveness, science, technology, and innovation policy. Since its launch in 2006, there have been thirteen meetings, which have allowed the Bank to stay in tune with the concerns and priorities of national authorities, to put them in contact with cutting edge research and new ideas, and to bring international experts to the region. Regional initiatives have been a byproduct of the dialogue, several of them financed through technical cooperation funding or the Regional Public Goods window. Among the IDB's tools in the sector, the Regional Policy Dialogue stands out as having the potential to become a key channel for the Bank to exercise its leadership and mainstream best practices in STI policy.

Lessons Learned from the IDB's Operational Experiences

Many lessons have been learned from the IDB's projects in STI. The following are collected from the Bank's operational experience in STI projects completed since 2009.[72]

Impact and Effectiveness of the IDB's Work in STI

A Missed Opportunity

One lesson stands apart as the most important. There is a stark contrast between the high impact and effectiveness of the Bank's work in STI and the overall limited effect that such work has produced when the economies are gauged by their competitive performance, their productivity growth, or the knowledge intensity and sophistication of their productive structure. In view of this, the policy-making process in STI clearly failed to spontaneously produce efficient outcomes over the decades across the region. Thus the Bank missed the opportunity to champion investments in the sector to a level that would have taken the region closer to the technological performance of their peers in Asia and the less developed regions of Europe, or prevented the wide productivity gap that has persisted between LAC and the advanced economies (Pagés, 2010).[73]

[72] An analysis of a sample of 11 operations in 9 countries was conducted by a team led by the Bank's Knowledge and Learning Sector in coordination with the Competitiveness and Innovation Division. The analysis is based on a desk review of operational documents, including the Project Completion Reports, and in-depth interviews with team leaders involved in both designing and implementing the lending programs, as well as a selection of leaders of national agencies responsible for execution. This section of this book also reflects the experiences of countries in STI policy-making, projects which are larger than the Bank's but closely intertwined with Bank operations in many instances.

[73] The IDB defines its pipeline of lending and technical assistance programs as part of the process of continuing a dialogue with national authorities in each borrowing country. The assertion here is that, in the absence of strong demand for investments in STI originating from nations, the Bank might have taken a more proactive stance. This highlights the importance of paying attention to the sector given its relevance as a necessary response to productivity stagnation in the region's economies.

Avoid Missing the Next Knowledge Revolution

Upcoming technological revolutions are anticipated worldwide, yet it is well established that developing economies will not automatically benefit from it in the absence of deliberate plans and effective policies. This calls for a correction in the Bank's STI efforts on two fronts. First, at the programming level, the IDB must deal with the consequences of the acute disparity between the rates of return on investment in innovation and the current level of investment in the sector. Therefore, the IDB needs to make innovation-related investments and integrate knowledge into the economies' priorities. Second, at the technical and operational levels, the Bank must put together an enhanced knowledge agenda that combines the instruments, programs, and policies incorporated in lending and technical cooperation programs into effective micro-level instruments and vehicles in order to affect overall economic performance.

Technical Cooperation Funds are Critical in Leveraging Resources for STI

The availability of technical cooperation funds focused on supporting STI operations has played a critical role on several fronts, including developing information availability and accumulating knowledge products in the sector. Above all, such funds have supported the pre-investment and design activities of larger operations, producing a leveraging effect that is tangible and hard to replicate in the absence of non-reimbursable funding.[74]

Institutional Support

Coordination, Coordination, Coordination

An effective STI sector requires intensive intra-governmental coordination as well as considerable dialogue and harmonization of public and private strategies and perspectives. It is key to adopt international best practices if major risks of dynamic inconsistency are to be avoided. Within the Bank, this reality requires better interaction between non-sovereign and sovereign operations aimed at maximizing the impact of the Bank's investments.

Work with the Institutions You Have

In the Bank's experience, it is important to build capabilities in critical institutional areas such as policy design, execution, management know-how, and information systems, even in cases where the institutional framework for the sector is weak or poorly defined. An interesting example of this has been the decision to implement

[74] Particularly worth mentioning is the role played by the Knowledge Partnership Korea Fund for Technology and Innovation and the Knowledge Economy Fund (a multi-donor thematic fund that has benefitted from contributions from Finland and Spain). In a recent report to donors, the Knowledge Economy Fund noted a strong leverage effect, mentioning that the ratio of non-reimbursable technical cooperation funds to larger lending programs that the Fund was instrumental in promoting and designing was 1:100 (ORP, 2011).

projects using ad hoc executing units created for Bank programs. Far from preventing national institutional development, in practice, building such capacity provides a platform for when a window of opportunity for institutional change presents itself. Waiting for the ideal institutional setting and mature capabilities before starting work in STI is not a productive strategy.[75]

Instrument Design

Building Capacity to Design and Manage Policy Instruments from the Ground Up

Experience shows that piecemeal development of policy instruments and the capability to manage them is a feasible and desirable strategy. This strategy has a good chance of leading to more sophisticated policies and executing agencies, develops capable human resources for policy design and management, and as it proceeds, generates valuable information that allows for course corrections and helps mitigate risk.

Incentive Compatibility Must Direct Evolution of Detailed Design

Over the years, the IDB has seen refinements in instrument design that have created features such as the requirement that firms benefiting from innovation incentives co-finance the project, competitive mechanisms in selecting projects that are to be publicly financed, and the relative advantages of non-reimbursable funding for innovation over traditional credit lines in several circumstances. These are all now standard features of operation design that are clearly understood today as features that mitigate agency problems and moral hazard. The search for further design refinements is ongoing.

A Learning Process in the Private Sector

The instruments that support individual businesses in effectively generating innovation capabilities and processes and technological modernization tend to be in high demand. However, these tools are limited in reaching many potentially innovative companies and may favor businesses with prior experience or that are already in networks. In many cases, firms may need support in project preparation and technological awareness to help them develop the basic skills needed to participate as full partners in opportunities afforded by public programs. In other cases, a sound combination of credit and non-reimbursable financing may support sustainability and a better incentive system, by focusing reimbursable instruments in areas of business upgrading that carry fewer externalities and reserving grants for projects with significant spillovers.

[75] This has to be understood in the context of pursuing the development of adequate institutional frameworks for STI over the long term, a major issue that will not be neglected by IDB operations.

Opportunities from Regional Integration

Regional integration may present unprecedented opportunities to widen market size and overcome scale and scope constraints in the functioning of innovation policy instruments. Recently, there has been growing demand from national authorities to integrate innovation and trade policy. The potential of trade agreements to facilitate and multiply the impact of conventional innovation policy instruments should become a part of their design.[76]

Scientific Activity Can Be Supported Effectively

Instruments for subsidizing competitive, peer-reviewed research projects have shown positive effects producing original knowledge and the amount and quality of scientific publications. They also play a role in developing highly skilled human resources and helping strengthen research capacity in universities and research institutes.

Excellence and Inclusion in Competitive Research Funding

A recurring issue in designing competitive grant funding for scientific research and firm innovation is that, since by necessity they are based on merit, resources are usually allocated to actors better placed to access these opportunities. In the LAC region, there has been a tradeoff between merit-based policies and diversity and inclusion. In other words, prioritizing excellence can imply less diversity and inclusion. A past operational response has used modalities such as targeted requests for proposals (e.g., young researchers, regional research institutions, and women entrepreneurs) to identify and support high-performance stakeholders among socially excluded groups without sacrificing the search for scientific excellence or productivity upgrading in firms.

Instrument Implementation

Instruments with Business Participation

Joint research projects between research institutions (such as universities) and firms present particular challenges. Time is needed for building trust as well as a system for resource and project management. Also, there is the search for common ground between the pursuit of research excellence and the production of knowledge that can be applied for productive purposes. To address these challenges, emerging responses,

[76] Based on their responsibilities, the Competitiveness and Innovation Division and the Integration and Trade Sector have provided LAC countries with analytical and operational support in their policy initiatives regarding innovation, and exports and foreign investment, respectively. In particular, whereas the Competitiveness and Innovation Division has thoroughly investigated the impact of innovation promotion programs in LAC, the Integration and Trade Sector has carried out extensive research on the effects of trade and investment promotion programs implemented throughout the region (e.g., Volpe Martincus and Carballo, 2010). Collaboration is ongoing. the Integration and Trade Sector has also supported LAC countries in negotiating and implementing trade agreements with regional and extra-regional partners. This is another area where the Competitiveness and Innovation Division and the Integration and Trade Sector are exploring further collaboration, building on the current trend to include innovation in trade partnerships.

which are based on experience, involve complementary factors such as: (i) developing innovation management skills in businesses; (ii) working within universities to improve links between society and business, and long-term collaboration; and (iii) setting up specialized technology transfer offices that can act as highly specialized bridges between businesses and academia. As for young systems with new business innovation programs, an effective starting point has been building awareness, extensive dialogue with the private sector, and partnerships involving potential firms incorporating innovation as an essential part of their activities.

Continuity and Complementarity of Supply Instruments

Experience shows that the regularity of requests for proposals and simultaneous supply of complementary instruments to support scientific research as well as firm innovation lends STI policy predictability and credibility. In an often overlooked special case, operational experience shows the importance of balancing strategies to support scientific development so that the increase in highly specialized human capital is accompanied by a proportional increase in infrastructure. Optimal design provides comprehensive packages of components, such as planning for repatriation of researchers while taking into account the availability of laboratories, equipment, space, and a supporting environment to ensure sustainability of the programming efforts.

Information Systems—Critical but Hard to Manage

Despite the progress made in strengthening and integrating information systems, there is still a long way to go. In particular, there are opportunities for improving in executing agency and public office information systems that increase productivity and efficiency, developing online assessment and monitoring projects, and creating automatically updated databases (and data sharing) that allow for impact assessments based on best international practices. Upgrading information and management systems (for innovation agencies) is highly complex and requires exceptional planning and management capabilities on top of all the other activities contemplated in almost any project.

Policy and Project Monitoring and Evaluation

Creating and consolidating a critical mass of local expertise with the skills to monitor and evaluate STI policies and programs is still a work in progress. The Bank's investments have spurred a leap forward in the region, but results are still far from adequate for high-quality and timely evaluations that are essential for evidence-based decision-making. Attention to this area must be maintained and reinforced in future operations.

Disseminate and Communicate Results

Making the Case for Innovation

Given that many of the products of investments in STI are intangible and complex, and are often poorly understood by decision-makers and the public at large, resources from each program must be reserved for disseminating information about the benefits to particular groups (e.g., SMEs and research institutions) and society at large. This is especially valid for new programs, where communication and dissemination have contributed to the participation of new beneficiaries and maintenance of demand. The Bank staff's expertise and connections to a worldwide network of knowledge sources play a key role in ongoing policy dialogue with authorities and stakeholders. Work with specialized communication consultants and the development of links with journalists who are familiar with the specialized STI topics have proven to be useful.

Making STI Investments Relevant for Society Goes Beyond Communication

Implementing social innovation programs using open innovation participatory platforms to find solutions to issues of social inclusion and poverty reduction has proved to be a powerful instrument in getting larger constituencies interested and involved in STI activities and policies. In this case, policy itself becomes the most effective message.

Preferred IDB Approaches and Areas of Activity

Based on the discussion to this point, the IDB must continue promoting and supporting public policies that encourage firm innovation, particularly in SMEs, establish an enabling environment for technology-based entrepreneurship, and ensure that complementary inputs and public goods indispensable for the success of the innovation system are in place (e.g., highly skilled human capital, scientific infrastructure, and research). Ultimately, adequate national innovation systems should play a critical role in enhancing firm productivity and hence providing a solid base for growing competitiveness across LAC economies. In addition, the Bank must support private sector investment through direct and indirect investment in firms or projects with innovative approaches that enhance productivity, increase market competition, improve environmental and social outcomes, and are financially sustainable. The Bank must also provide technical assistance to support such firms and projects. These efforts seek to lever the knowledge, capital, and technology of the private sector to bridge the productivity gap in LAC.

The Bank's strengths put it in a privileged position to deepen support for the sector by maximizing the impacts of the reforms and programs financed. In LAC, interest in innovation policy is growing in the private and public sectors, primarily because of the impact of technological change on the economy worldwide. This means the Bank is likely to see growing demand for its financial and technical assistance services in STI. This does not translate into the Bank becoming involved in every possible aspect of STI policy, but the systemic approach it espouses inevitably leads to the ability to act effectively whether a particular request for support involves business, the public sector, or the academic pillars of the innovation system. The Bank must stay focused and avoid becoming overextended by carefully targeting its programs to those activities that are likely to have the most direct effect on productivity and competitiveness and those that generate the most extensive externalities. Thus, for example, if highly skilled scientific and engineering personnel are key components of what a given economy needs in order to enhance its knowledge intensity, the Bank would support specific scholarship or talent acquisition programs as opposed to wholesale university reforms that are a more indirect path to the objectives. Along the same lines, if support for firm innovation is the goal, the IDB would do better to concentrate on maximizing externalities rather than dealing with areas that the regular financial market can normally handle, such as credit to acquire machinery.

Considerable heterogeneity in developing national innovation systems and in the economic structure of borrowing countries dictates the need to advance operation designs and implementation strategies on a case-by-case basis. Three main criteria will direct the choices: (i) the pre-existing institutional capacity to implement particular programs or reforms; (ii) the distance of the main economic sectors affected by the operation to the technological frontier and their potential as a basis for economic diversification[77]; and (iii) the degree of development of knowledge infrastructure (e.g., local availability of inputs for innovation). A discussion of how these principles are to be combined and an illustration of how this would dictate different types of intervention in LAC countries at diverse levels of economic development are provided in Table 2 (page 45).

To the extent possible, the following general principles will underlie the Bank's operational and knowledge work in the STI sector:

(i) Build institutional capacity in national innovation systems following internationally sanctioned best practices.

(ii) Respond to clearly identified market failure or coordination failure.

(iii) Minimize and mitigate the risk of capture by stakeholders and dynamic inconsistency in their execution with interventions and design.

(iv) Strive to develop STI lending and technical assistance programs tailored to the specific material, intellectual, and institutional resources of each country at any given time.

[77] See Crespi, Fernández-Arias, and Stein (2014) for guidelines regarding how to operationally assess this criterion.

(v) Ensure programs and activities are evaluable and sustain efforts to improve data availability for carrying out impact evaluations.

(vi) Include activities and resources devoted to better communication of results and impacts.

Five dimensions of success have been defined as distinctive signs that the goal of effectively supporting STI policy is being reached and that LAC economies are becoming more knowledge intensive. The dimensions relate to growing investment in STI across LAC economies, ensuring appropriate financing of business innovation, building adequate scientific and technological capabilities, increasing the availability of highly qualified human capital for innovation, and improving the business and innovation climate.

The five dimensions are the combined result of what the IDB knows about what works in innovation and science policy, the particular challenges facing the region in this sector, and what the IDB has learned through its hands-on involvement. They are built on the belief, strongly backed by recent economic development history, that well focused and significant efforts can make a difference and turn economies around in one generation, taking productivity, social welfare, and competitiveness to a new level based on the intense incorporation of knowledge in the economy. Technological leap-frogging and catching-up are difficult, thus few developing countries have succeeded. However, there are success stories (e.g., Finland, Israel, and South Korea) that prove such processes are possible and provide signals regarding possible paths forward (see Appendix 2).

Dimensions of Success

Dimension 1. Public and private investment in STI reduces the innovation shortage typical of LAC economies, perceptibly decreasing the gap between the region and advanced economies

In response to the tendency of the STI policy-making process to result in sub-optimal levels of investment in the sector, the Bank should be proactive and exercise leadership in promoting a correction in this trend. Of note are high returns on investment in innovation, the experience of recent success stories in development and competitiveness in emerging economies (see Appendix 2), and overall trends that dictate accelerated knowledge intensity across all sectors of the economy. The following are three proposed lines of action:

(i) Support capacity building to enhance institutional, technical, and managerial performance in the STI policy-making process. Stronger and more capable institutions are necessary for improving public investment in STI and creating the possibility that public policy will become an effective tool for integrating knowledge into economic activity.

(ii) Contribute to better-financed public policy to improve the baseline of low public investment in STI. An upward trend across the region should start reducing the current insufficient correction of market failures negatively affecting innovation activity in the region.

(iii) Mainstream the application of innovation-related approaches (e.g., open innovation, design thinking, and Web 2.0 Internet platforms) to developing novel solutions to social issues (e.g., access to social services and social inclusion).

Dimension 2. A larger share of firms in the region, particularly SMEs and startups, gain better access to adequate financing for investments in technology and innovation, and consequently increase the knowledge content of the goods and services that they produce and export

The IDB should ensure continuity and expand its lending operations that provide both non-reimbursable and reimbursable support to encourage existing firms to innovate. The Bank should also support fast growing innovative startups so they can operate in a context where seed, angel, and venture capital financing is available. The low level of private investment in innovation in LAC is a key issue to be addressed if the region's productivity gap in relation to other regions of the world is to be reduced.

The main lines of action proposed are to maintain and deepen the primary focus of Bank operations in STI on promoting and accelerating the productive uses of knowledge in firms. Productivity growth should be one of the underlying objectives of most IDB STI operations, and tearing down the barriers that prevent knowledge from being created, acquired, disseminated, and used in productive activities must be considered an overall priority.

Dimension 3. LAC economies make observable gains in obtaining the highly skilled human capital necessary to support and further develop their innovation systems

There is growing awareness across LAC that highly skilled human capital is a key component of STI development. Innovation systems require not only scientific researchers with advanced training, but also entrepreneurial talent, well-educated engineers and technicians, and a full array of professionals, such as technology and innovation managers, lawyers with expertise in intellectual property rights, knowledge brokers, and designers. The following two lines of action are proposed:

(i) Sustain and deepen Bank support for scholarship programs that target science, technology, engineering, and mathematics (STEM) fields.

(ii) Support a new generation of talent acquisition programs that seek to accelerate the availability of highly skilled human capital in LAC. This should be achieved through diaspora management, selective immigration, and incentives for the return of nationals working abroad in STEM fields or in dynamic entrepreneurship and other key areas for developing innovation ecosystems.

Dimension 4. Public and private investment in technological and scientific infrastructure grows to a level closer to that needed to provide adequate inputs for each economy in the region, thus becoming better able to identify, understand, adapt, and productively utilize the best available production processes

Accelerated technology adoption in firms requires a minimum of complementary investments in scientific and technological capabilities. The level and specific design that these complementary investments should take vary according to the level of sophistication and diversification of the economy, but as such they are an unavoidable component of successful STI policy.

This dimension translates into one line of action: provide support, in the context of the Bank's lending and technical assistance operations, to scientific research, laboratory equipment, quality systems, and metrology services.

Dimension 5. The business and innovation climate for private sector development and more intense firm innovation improves across the region, as measured by consistent business climate and innovation indexes

In response to the ample room for improvement in the business climate and competitiveness-related regulation in most LAC countries, the Bank must focus on the innovation climate. This focus will help firms do business in a significantly new and more productive way using innovation and technology. The following are two proposed lines of action:

(i) Incorporate elements of innovation climate in reforms to competitiveness policy-based loans, aiming at producing systemic impacts through reforms in regulations affecting innovation in areas such as commercialization of intangible assets through intellectual property[78] and venture financing.

(ii) Prioritize investments to develop effective innovation ecosystems in lending and technical assistance operations.

[78] LAC countries register wide normative and institutional variation in intellectual property rights. The Bank always adapts actions in this sphere to local conditions and regulations. However, the IDB's distinctive approach will be used in all cases. The objective is to enhance an economy's capacity to develop markets in which ideas and knowledge can acquire economic value through capacity building, talent development, and the dissemination of skills relevant to STI in the region's innovation systems.

Appendix 1. IDB Loan and Technical Cooperation Operations in the Science, Technology and Innovation Sector

Table 1. Active (Current) Loan Operations in the Competitiveness and Innovation Division

#	Country	Operation Name	Amount Approved (US$M)	Approval Year
1	Argentina	Norte Grande Competitiveness Program	16	2008
2	Argentina	Development of Satellite System and Applications Program	50	2006
3	Argentina	SMEs Credit Access and Competitiveness	50	2007
4	Argentina	CCLIP: Program of Technological Innovation	100	2009
5	Argentina	Technological Innovation Program II	200	2010
6	Argentina	Technological Innovation Program III	200	2012
7	Argentina	MSME Competitiveness Support Program	50	2013
8	Argentina	Competitiveness of Regional Economies	200	2014
9	Argentina	Science and Technology Scholarships - Program BEC.AR	24	2013
10	Argentina	Program for the Technological Developmentof Mendoza	50	2014
11	Barbados	Barbados Competitiveness Program	10	2009
12	Brazil	Competitiveness of Business in Local Production Systems in São Paulo	10	2007
13	Brazil	Innovation and Dissemination Local Cluster Competitiveness State of Pernambuco	10	2009
14	Brazil	Cluster Competitiveness Support Program for Minas Gerais	10	2009
15	Brazil	Strengthening of the Entrepreneurial Activity Program Estado de Bahía	10	2006
16	Colombia	Strengthen the National Science, Technology, and Innovation System, Phase I	25	2010
17	Costa Rica	Innovation and Human Capital for Competitiveness Program	35	2012

#	Country	Operation Name	Amount Approved (US$M)	Approval Year
18	Dominican Republic	Program to Support Competitiveness Policy II	10	2010
19	Dominican Republic	Business Development & Competitiveness in the Province of San Juan	35	2013
20	El Salvador	Innovation for Competitiveness Program	30	2012
21	El Salvador	Productive Corridors Program	40	2014
22	Guatemala	Program to Support Strategic Investments and Productive Transformation	29	2006
23	Guyana	Support for Competitiveness	8.65	2006
24	Peru	Innovation Project for Competitiveness	35	2012
25	Peru	Program for Improving Productivity and Competitiveness	5	2010
26	Panama	Multiphase Technological Transformation Program-Phase I	19.7	2008
27	Paraguay	Enterprise Development for SME	7.90	2001
28	Paraguay	Science and Technology Program	6.39	2005
29	Uruguay	Clusters Competitiveness and Value Chains	9	2006
30	Uruguay	Technology Development Program II	34	2008
31	Uruguay	Program to Support Future Entrepreneurs	8	2012
31	**TOTAL**		**1,327.64**	

Notes: Other international financial institutions have smaller active portfolios in LAC. For example, the International Finance Corporation has US$155 million in open commitments for innovation and entrepreneurship, and The World Bank has US$954 million in active lending for innovation components.

Source: IDB Operations Portal System.

Table 2. Active (Current) Technical Cooperation Operations in the Competitiveness and Innovation Division

Count	Country	Approval Year(s)	Total Amount Approved (US$000)
2	Argentina	2010, 2012	760
5	Brazil	2009, 2010, 2013	2,450.2
2	Colombia	2010, 2012	636
2	Costa Rica	2011, 2012	288
1	El Salvador	2012	160
1	Mexico	2011	100
2	Peru	2014	617.9
2	Panama	2012	455
1	Paraguay	2013	165
1	Trinidad and Tobago	2013	260
1	Uruguay	2013	170
16	Regional	2008 - 2014	8,990.3
36	**TOTAL**		**15,052.4**

Source: IDB Operations Portal System.

Table 3. IDB Loan and Technical Cooperation Operations in the Science, Technology and Innovation Sector, 1967 to 2014

Country	Count of Loans	Count of TCs
Argentina	6	7
Barbados	0	1
Belize	0	1
Bolivia	3	1
Brazil	8	2
Chile	7	6
Colombia	4	8
Costa Rica	2	11
Dominican Republic	1	7
Ecuador	3	7
El Salvador	0	4
Guatemala	2	1
Guyana	1	1
Haiti	0	1
Honduras	1	7
Jamaica	2	2
Mexico	6	9
Nicaragua	1	7
Peru	2	8
Panama	3	6
Paraguay	2	1
Suriname	0	3
Uruguay	2	5
Venezuela	2	7
Regional	0	38
TOTAL	**58**	**151**

Notes: Operations with approval year before 2014 and after 1967 have been included. Over that time period, the total approved amount lent was US$2.1 billion and the total for non-reimbursable technical assistance (TCs), US$23 million.

Source: IDB Operations Portal System.

Appendix 2. Getting Prosperous Through Ideas: How to Turn Around Economies by Investing in Innovation

There are outstanding examples of success in recent economic development history. Success is understood as countries that, in one generation and starting from a low level of income, have achieved a profound structural change in their economies, turning them into high-productivity engines that have become technological leaders worldwide. Further, these countries have developed considerable resilience to external shocks. The following accounts of three cases—Finland, Israel, and South Korea—show that the path to knowledge-based development is not a single, linear, easy-to-follow path. Each country's journey was dictated by circumstances, opportunities, and pre-existing endowments and constraints. Yet several common threads are easily identified: long-term commitment; flexible, smart, state-of-the-art public policy; large investments in knowledge diffusion, transfer, and creation; institution building and coordination; and last, but not least, various forms of private sector-centered policies.

Finland: Top Performer in Innovation, Education and ICT Industry

Source: OECD (2005)

At the time of World War II, Finland was an agricultural society whose primary export was raw materials (50 percent of exports). In just one generation, Finland achieved massive structural change, with 50 percent of exports consisting of electronics and machinery by 2005. The country had a variety of favorable initial conditions, such as strong cultural homogeneity, a tradition of education being a high priority, good quality infrastructure, and the capacity to absorb external technology. But, a key factor in its productive transformation was the creation of a solid system to support innovation. Further, the system and the related public policies have been able to react to external economic crises. It is instructive to review the evolution of Finland's innovation policy through its three principal stages.

Building the System

During the first two decades after World War II, in a context of a relatively closed and highly regulated economy, the focus was on strong support for investment in advanced human capital by establishing regional universities and polytechnics, and expanding vocational education. In 1967, the Finnish Innovation Fund (SITRA) was created to promote research and product development in firms. It provided loans and grants, and focused innovation policy on supporting traditional sectors (e.g., forestry and associated machinery).

Crisis Disruption and Reaction I

The oil crisis of the mid-1970s put enormous pressure on the Finnish economy, bringing high inflation and unemployment rates. The government's reaction was a mix of policies aimed at diversifying the economy. One set of policies included a measure of deregulation and increased competition by gradually opening the economy to foreign trade, lifting price controls, deregulating telecoms, and liberalizing financial markets. Also, and perhaps more relevant, was the appointment of the "Technological Committee" in 1980. This committee (comprising unions, researchers, and private and public sector representatives) agreed to strengthen innovation policies, set a target for R&D spending of 1 percent of GDP, and focus policy on the diffusion of three general purpose technologies: microelectronics, biotechnology, and new materials. Following this impulse, and based on SITRA's experience, the Finnish Funding Agency for Technology and Innovation (TEKES) was created. TEKES began operating with a programmatic focus on the target technologies and prioritized competitive grants that required collaboration between universities and industry. Coordinating the state agencies active in innovation policy was delegated to the newly created Finnish Science and Technology Council in 1987.

Crisis Disruption and Reaction II

The collapse of the Union of Soviet Socialist Republics (USSR) in 1990, which was a significant market for Finland's exports, caused a severe economic crisis. The negative impact was observed in a steep decline in GDP and unemployment rates approaching 20 percent. Nevertheless, Finland quickly recovered from the crisis, based mainly on rapid growth in exports. This exceptional recovery was primarily the consequence of the public policies started in the 1980s and the continuation of deregulating telecoms, opening the economy, and prioritizing innovation policies. The ICT sector, strongly supported the decade previously, revealed itself to be highly competitive (mobile phones), and universities (with flexible programs) provided the skilled human capital the sector required. The pool of skilled workers was enriched through tax incentives to firms to incorporate international experts, and scholarships to attract foreign students. Furthermore, the country radically increased its R&D budget, doubling TEKES's budget between 1990 and 1995.

Today, Finland's policies are increasingly focused on innovation policies to support clusters and collaborations among firms and between firms and research institutions. About 50 percent of TEKES's R&D funding is distributed through technology programs carried out jointly by firms, research institutes, and universities. This cooperation is a pre-condition for obtaining funding for a national technology program. Networking with smaller firms is a key criterion for TEKES's R&D funding directed to large firms. As a consequence, SMEs receive over 50 percent of all R&D public funding for the business enterprise sector. Thus, TEKES ends up supporting intense knowledge spillovers.

Israel: The Start-up Nation

Source: Avnimelech and Teubal (2008)

Being one of the most successful stories about transformation of an economy from low to high technology sectors, Israel is an example of how to develop a system that supports technological progress. By the mid-1960s, Israel had significant technological and higher education infrastructure as a result of a process that began in 1925 under British rule. The subsequent innovation policy process can be organized into the following three steps.

Background Conditions Phase (1969–1984)

During this phase, on the one hand, the government boosted the supply of advanced human capital by establishing three new universities and several applied research institutes. On the other hand, a new institutional setting for innovation policy was put in place in 1969 with the creation of the Office of the Chief Scientist at the Ministry of Industry and Trade. The office provided horizontal subsidies to R&D in the business sector, mostly to individual firms oriented to export markets. Furthermore, it provided incentives to R&D performed by multinationals in Israel and targeted support to the defense industry.

Pre-emergence Phase (1985–1992)

This stage was primarily focused on improving framework conditions by increasing competition and stabilizing the macroeconomic environment. Public financing for innovation was expanded, this time by passing a law that increased subsidies to business R&D. At the same time, the defense industry faced a decrease in funding, which injected a pool of engineers and skilled high technology workers into the economy; these people often became entrepreneurs. Toward the end of this phase, the ICT industry was revealing itself to be competitive. These efforts were complemented with horizontal programs (the Magnet Program) aimed at supporting collaborative innovation and technology incubators.

Emergence Phase (1993–2000)

The results of the previous innovation efforts generated enough deal flow and a proper technical human capital base, but the system was still lacking adequate funding. About 60 percent of technically successful innovation projects failed due to a lack of funding for further development as well as poor management skills. To address these issues, Israel implemented the Yozma Program: a Fund of Funds based on the limited partnership model. The program set up 10 privately owned funds with up to 40 percent public funding and was managed by venture capital companies with reputable expertise. The funds had upside incentives of a five-year option to buy government shares at cost. This successful program led to full privatization of the initiative in 1998 and was key to consolidating innovation as a central element of Israel's economic performance.

Innovation Policy Building by Catching-Up: South Korea

Sources: Lee (2013) and OECD (2009b)

South Korea has been one of the most successful latecomer economies in achieving rapid economic growth, and it is approaching the ranks of advanced economies in terms of GDP per capita. One element of South Korea's success has been its emphasis on capability and technological development, which has led to consolidating private exporting and R&D capacity. During the catch-up process, South Korea went through four different phases. In each phase, the government implemented innovation policies using a broad range of instruments.

Initial Efforts (1960s to mid-1970s)

In the 1960s, when South Korea began its modernization process, the country faced two key barriers: low technological capabilities of domestic firms and weak human capital (in particular, in applied sciences and engineering). In this context, the government focused on encouraging technology imports with licensing, developing a new graduate school of engineering and applied sciences (the Korean Institute of Science and Technology, KIST), and setting up key institutions for science and technology infrastructure. These actions facilitated the absorption of imported technologies and contributed to attracting technology-based foreign direct investment. During this stage, domestic firms were involved only in assembling and packaging processes, with very limited investment in innovation. For the South Korean firms, this was a learning-by-doing period, without any explicit attempt to develop new capabilities or technologies. During this period, R&D investment was never higher than 0.5 percent of GDP.

More Active Catch-up Phase (mid-1970s to mid-1980s)

In this second phase, South Korean firms became more active in adopting foreign technologies by imitative innovation and reverse engineering. They invested more intensively in adapting foreign technology and in developing local technological capabilities, mainly through technological licensing and knowledge transfer. The government focused on technological development by funding private R&D through tax incentives, and by conducting R&D activities directly and sharing the results with private firms. In the 1980s, a public–private joint R&D program was set up to support higher-risk projects. Consequently, the R&D to gross national product (GNP) ratio increased from 0.42 percent in 1975 to 1.41 percent in 1985. During this stage, government investment in R&D was still greater than private sector investment.

Rapid Catch-up (mid-1980s to mid-1990s)

This third phase was a period of rapid catch-up led by the major South Korean businesses. Firms increased production of knowledge-intensive products and started to develop new products. Realizing the limits of a strategy based on licensing and embodied technology transfer, firms started to establish in-house R&D centers. To encourage this trend, the government eased the accreditation process necessary for setting up private R&D institutes, leading to the creation of a large number of institutes. The R&D/GNP ratio increased from 1.41 percent in 1985 to 2.32 percent in 1994. Such active engagement of private R&D activities enabled South Korea to absorb the newly emerging technologies. From this period onward, private R&D investment has been a key part of the South Korean innovation and technology development process, accounting for more than 70 percent of total R&D investment.

Maturing of the Catch-up Phase (mid-1990s to present)

As South Korea approaches the technological frontier, the country is entering a new and critical phase in its development. With growth of labor and capital inputs slowing and increasing competition from new industrializing countries, South Korea faces new challenges. The catch-up model is now under stress, and South Korea is shifting from a catch-up to a creative innovation system. The creative model requires increased spending on R&D by both the public and private sectors and improved knowledge flows and technology transfer across the system. Stronger support is needed for SMEs and startups, as well as in increasing the role of longer-term fundamental research, developing research capacity in the universities, and addressing lagging productivity in services. This transition toward a creative economy can already be seen in some innovation indicators. Patents owned by South Koreans increased from 7 in 1982 to 3,558 in 1999 according to a U.S. register. In 2006, the R&D/GNP ratio passed the 3 percent threshold.

References

Acs, Z., and D. Audretsch. 1989. "Small-Firm Entry in U.S. Manufacturing." *Economica*, 56(222):255–65.

Aghion, P., S. Bechtold, L. Cassar, and H. Herz. 2014. "The Causal Effects of Competition on Innovation: Experimental Evidence." Working Paper No. 19987. Cambridge, MA: The National Bureau of Economic Research (NBER).

Aghion, P., P. David, and D. Foray. 2009. "Science, Technology, and Innovation for Economic Growth: Linking Policy Research and Practice in STIG Systems." *Research Policy*, 38(4):681–93.

Aghion, P., and R. Griffith. 2006. "Competition and Growth: Reconciling Theory and Evidence." Cambridge, MA: MIT Press.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *Quarterly Journal of Economics*, 120(2):701–28.

Aghion, P., C. Harris, P. Howitt, and J. Vickers. 2001. "Competition, Imitation, and Growth with Step-by-Step Innovation." *Review of Economic Studies*, 68:467–92.

Aghion, P., and P. Howitt. 1992. "A Model of Growth through Creative Destruction." *Econometrica*, 60(2):323–51.

Alves de Mendonça, M.A., F. Freitas, and J.M. de Souza. 2008. "Information Technology and Productivity: Evidence for Brazilian Industry from Firm-level Data." *Information Technology for Development*, 14(2):136–53.

ANII. 2008. III Encuesta de Actividades de Innovación en la Industria Uruguaya (2004-06). Montevideo, Uruguay: *Agencia Nacional de Investigación e Innovación*.

Aninat, C., J.M. Benavente, I. Briones, N. Eyzaguirre, P. Navia, and J. Olivari. 2010. "The Political Economy of Productivity: The Case of Chile." Working Paper No. 105. Washington, DC: Inter-American Development Bank (IDB).

Anlló, G., and D. Suárez. "Innovación: Algo más que I+D. Evidencias Iberoamericanas a Partir de las Encuestas de Innovación: Construyendo las Estrategias Empresarias competitivas." Buenos Aires, Argentina: Economic Commission for Latin America and the Caribbean (ECLAC)-REDES.

Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Invention." In R. Nelson, editor. *The Rate and Direction of Inventive Activity.* Princeton, NJ: Princeton University Press.

Arza, V. 2010. “Vinculaciones entre organismos públicos de investigación y empresas en Lationamérica.” Argentina, Mimeo.

Arias-Ortiz, E., G. Crespi, A. Rasteletti, and F. Vargas. 2014. “Productivity in Services in Latin America and the Caribbean.” Discussion Paper No. 346. Washington, DC: IDB.

Audretsch, D.B., and M. Keilbach. 2003. “Entrepreneurship Capital and Economic Performance.” Discussion Paper 3678. London, UK: Centre for Economic Policy Research.

Avalos, I. 2002. “El Programa de Agendas de Investigación como intento de asociar a los tres sectores: Experiencias en Venezuela.” Washington, DC: IDB.

Avnimelech, G., and M. Teubal. 2008. “The Emergence of Israel’s Venture Capital Industry: How Policy Can Influence Cluster Dynamics.” In P. Braunerhjelm and M. Feldman, *Cluster Genesis: Technology-Based Industrial Development*. Oxford: Oxford University Press.

Aw, B.Y., M.J. Roberts, and D. Yi Xu. 2008. “R&D Investments, Exporting, and the Evolution of Firm Productivity.” *The American Economic Review,* 98(2):451–56.

Benavente, J.M., J. De Gregorio, and M. Nuñez. 2005. “Rates of Return for Industrial R&D in Chile.” Working Paper. Santiago, Chile: Economic Department of the University of Chile.

Benavente, J.M., G. Crespi, and A. Maffioli. 2007. “Public Support to Firm Innovation: The Chilean FONTEC Experience.” Office of Evaluation and Oversight (OVE) Working Paper No. 0407. Washington, DC: IDB.

Benavente, J., and C. Bravo. 2009. “Innovation, R&D Investment, and Productivity in Latin American and Caribbean Firms: The Chilean Case.” Washington, DC: Latin American and Caribbean Research Network, IDB.

Bloom, N., and J. Van Reenen. 2010. “Why Do Management Practices Differ across Firms and Countries?” *Journal of Economic Perspectives*, 24(1):203–24.

Blundell, R., R. Griffith, and J.V. Reenen. 1999. “Market Share, Market Value, and Innovation in a Panel of British Manufacturing Firms.” *Review of Economic Studies*, 66:529–54.

Bresnahan, T.F., and M. Trajtenberg. 1995. “General Purpose Technologies: Engines of Growth?” Working Paper 4148. Cambridge, MA: NBER.

Castillo, V., A. Maffioli, S. Rojo, and R. Stucchi. 2014. “Knowledge Spillovers of Innovation Policy through Labor Mobility: An Impact Evaluation of the FONTAR Program in Argentina.” Working Paper No. 488. Washington, DC: IDB.

Chen, D., and C. Dahlman. 2005. "The Knowledge Economy, the KAM Methodology, and World Bank Operations." Manuscript. Washington, DC: World Bank.

Chong, A., ed. 2011. *Development Connections: Unveiling the Impact of New Information Technologies.* Development in the Americas. Washington, DC: IDB and Palgrave-Macmillan.

Chrisney, M.D., and R. Monge-Gonzalez. 2013. "Los servicios de desarrollo productivo y el papel de los bancos públicos de desarrollo." In F. de Olloqui, editor, *Bancos públicos de desarrollo: hacia un nuevo paradigma?* Washington, DC: IDB.

Chudnovsky, D., A. López, M. Rossi, and D. Ubfal. 2006. "Evaluating a Program of Public Funding of Private Innovation Activities. An Econometric Study of FONTAR in Argentina." OVE Working Paper No. 1606. Washington, DC: IDB.

CIEPLAN. 2013. *Recursos Naturales y Diversificación Exportadora. Una mirada de futuro para América Latina.* Santiago, Chile: Corporación de Estudios para Latinoamérica.

Cimoli, M., M. Holland, G. Porcille, A. Primi, and S. Vergara. 2006. "Growth, Structural Change, and Technological Capabilities Latin American in a Comparative Perspective." Laboratory of Economics and Management, Working Paper Series. PISA, Italy: Sant'Anna School of Advanced Studies.

Cimoli, M. (coordinator). 2010. "Vínculos entre universidades y empresas para el desarrollo tecnológico." Santiago, Chile: American General Secretariat of the Economic Commission for Latin America and the Caribbean (ECLAC).

Cockburn, I., J. Lanjouw, and M. Schankerman. 2014. "Patents and the Global Diffusion of New Drugs." Working Paper 20492. Cambridge, MA: NBER.

Cohen, W.M. 2010. "Fifty Years of Empirical Studies of Innovative Activity and Performance." In B. H. Hall and N. Rosenberg, eds., *Handbook of the Economics of Innovation*, Vol. 1. Amsterdam: Elsevier B.V.

Cohen, W.M., and D.A. Levinthal. 1989. "Innovation and Learning: The Two Faces of R&D." *The Economic Journal,* 99(397):569–96.

———. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly,* 35(1):128–52.

Comin, D., B. Hobijn, and E. Rovito. 2006. "Five Facts You Need to Know About Technology Diffusion." Working Paper 11928. Cambridge, MA: NBER.

Corbacho, A., coordinator. 2012. *The Fiscal Institutions of Tomorrow*. Washington, DC: IDB.

Crépon, B., E. Duguet, and J. Mairesse. 1998. “Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level.” Working Paper 1-43. Cambridge, MA: NBER.

Crespi, G. 2012. “Fiscal Incentives for Business Innovation.” In A. Corbacho, coordinator, *The Fiscal Institutions of Tomorrow*. Washington, DC: IDB.

Crespi, G., A. Maffioli, and M. Meléndez. 2011. “Public Support to Innovation: The Colombian COLCIENCIAS’ Experience.” Publication 38498. Washington, DC: IDB.

Crespi, G., A. Maffioli, P. Mohnen, and G. Vazquez. 2011. “Evaluating the Impact of Science, Technology, and Innovation Programs: A Methodological Toolkit.” IDB Technical Note No. IDB-TN-333. Washington, DC: IDB. http://publications.iadb.org/handle/11319/5396.

Crespi, G., and P. Zuñiga. 2010. “Innovation and Productivity: Evidence from Six Latin American Countries.” Working Paper Series No. 218. Washington, DC: IDB.

Crespi, G., E. Fernández-Arias, and E. Stein, editors. 2014. “Rethinking Productive Development: Sound Policies and Institutions for Economic Transformation.” *Development in the Americas.* Washington, DC: IDB and Palgrave-Macmillan.

Crespi, G., E. Tacsir, and F. Vargas. 2014. “Innovation and Productivity in Services: Empirical Evidence from Latin America.” Technical Note No. 690. Washington, DC: IDB.

Criscuolo, C., P. Gal, and C. Menon. 2014. “The Dynamics of Employment Growth: New Evidence from 18 Countries.” Science, Technology, and Industry Policy Paper No. 14. Paris, France: Organisation for Economic Co-operation and Development (OECD).

Daude, C., and E. Fernandez Arias. 2010. “Aggregate Productivity: The Key for Latin American Development.” In C. Pagés, ed., *The Age of Productivity.* Development in the Americas Series. Washington DC: IDB and Palgrave-Macmillan.

De León, I. Forthcoming. “Capitalización de Innovaciones para Colombia: Propuesta para la comercialización de activos intangibles.” Washington, DC: IDB.

De Negri J.A., M. Borges Lemos, and F. De Negri. 2006a. “Impact of R&D Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms.” OVE Working Paper No. 1406. Washington, DC: IDB.

———. 2006b. “The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms.” OVE Working Paper No. 1306. Washington, DC: IDB.

Disney, R., J. Haskel, and Y. Heden. 2003. "Restructuring and Productivity Growth in UK Manufacturing." *Economic Journal, Royal Economic Society*, 113(489):666–94.

Docquier, F., and M. Schiff. 2008. "Measuring Skilled Emigration Rates: The Case of Small States." Discussion Paper 3386. Bonn, Germany: IZA.

Egler, I., W. Peres, and S. Rovira (eds.). 2014. "La integración productiva latinoamericana mediante proyectos regionales en ciencia, tecnología e innovación." Santiago, Chile: ECLAC.

Fagerberg, J., and B. Verspagen. 2002. "Technology Gaps, Innovation Diffusion, and Transformation: An Evolutionary Approach." *Research Policy*, 31:1291–304.

Figueiredo, P.N. 2013. "Beyond Technological Catch-up: An Empirical Investigation of Further Innovative Capability Accumulation Outcomes in Latecomer Firms with Evidence from Brazil (No. 048)." Maastricht, The Netherlands: United Nations University, Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT).

Foray, D. 2007. "Enriching the Indicator Base for the Economics of Knowledge." In *Science, Technology, and Innovation Indicators in a Changing World: Responding to Policy Needs.* Paris, France: OECD.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London, England: Pinter.

Garcia-Robles, S. 2011. "The Multilateral investment Fund: Lessons Learned Building a Local Venture Capital Industry in Latin America and the Caribbean." *Venture Equity Latin America and Latin American Law & Business Report*.

Greenwald, B., and J. Stiglitz. 1989. "Financial Market Imperfections and Productivity Growth." Working Paper Series 206. Stockholm, Sweden: Research Institute of Industrial Economics.

Griffith, R., S. Redding, and J. Van Reenen. 2004. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." *Review of Economics and Statistics*, 86(4):883–95.

Griliches, Z. 1979. "Issues in Assessing the Contribution of Research and Development to Productivity Growth." *Bell Journal of Economics*, 10(1):92–116.

———. 1986. "Productivity, R&D, and Basic Research at the Firm Level in the 1970s." *American Economic Review*, 76(1):141–54.

Girma, S., H. Gorg, and M. Pisu. 2008. “Exporting, Linkages, and Productivity Spillovers from Foreign Direct Investment.” *Canadian Journal of Economics*, 41(1):320–34.

Goñi, E., and W.F. Maloney. 2014. “Why Don’t Poor Countries Do R&D?” Policy Research Working Paper 6811. Washington, DC: The World Bank.

Guaipatin, C., and L. Schwartz. 2014. “Ecuador: Análisis del Sistema Nacional de Innovación. Hacia la consolidación de una cultura innovadora.” Monograph. Washington, DC: IDB.

Guinet, J. 2014. “Assessment of the National Innovation Ecosystem of Trinidad and Tobago. Final Report.” Washington, DC: IDB.

Hall, B. H. and D. Harhoff. 2012. “Recent Research on the Economics of Patents.” *Annual Review of Economics*, 4:541–65.

Hall, B.H., and J. Lerner. 2010. “The Financing of R&D and Innovation.” Working Paper 012. Maastricht, The Netherlands: UNU-MERIT.

Hall, B., and A. Maffioli. 2007. “IDB’s Science and Technology Programs: An Evaluation of the Technology Development Funds (TDF) and Competitive Research Grants (CRG).” OVE Evaluation Report. Washington, DC: IDB.

———. 2008. “Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America.” Working Paper 13835. Cambridge, MA: NBER.

Hall, B., J. Mairesse, and P. Mohnen. 2009. “Measuring the Returns to R&D.” Working Paper No. W15622. Cambridge, MA: NBER.

Hall, R., and C. Jones. 1999. “Why Do Some Countries Produce So Much More Output Per Worker Than Others?” *The Quarterly Journal of Economics*, 14(1):83–116.

Hall, B. and J. Mairesse. 1995. “Exploring the Relationship between R&D and Productivity in French Manufacturing Firms.” *Journal of Econometrics*, 65:263–93.

Haltiwanger, J., R.S. Jarmin, and J. Miranda. 2013. “Who Creates Jobs? Small vs. Large vs. Young.” *The Review of Economics and Statistics*, XCV(2):347–61.

Hallward-Driemeier, M., and L. Pritchett. 2011. “How Business Is Done and the ‘Doing Business’ Indicators: The Investment Climate When Firms Have Climate Control.” Policy Research Working Paper Series 5563. Washington, DC: The World Bank.

Hart, O.D. 1980. "Perfect Competition and Optimal Product Differentiation." *Journal of Economic Theory*, 22:279–312.

Hausmann, R., D. Rodrik, and C.F. Sabel. 2008. "Reconfiguring Industrial Policy: A Framework with an Application to South Africa." Working Paper No. 168. Cambridge, MA: Center for International Development, Harvard University.

Hausmann, R., C.A. Hidalgo, J. Jiménez, R. Lawrence, E. Levy Yeyati, C. Sabel, and D. Schydlowsky. 2011. "Construyendo un mejor futuro para la República Dominicana: herramientas para el desarrollo." Technical report. Cambridge, MA: Center for International Development, Harvard University.

Hellmann, T., and M. Puri. 2002. "Venture Capital and the Professionalization of Start-Up Firms." *The Journal of Finance*, 57(1):167–97.

Hertog, P. den. 2010. "Managing Service Innovation: Firm-level Dynamic Capabilities and Policy Options." Utrecht, The Netherlands: Dialogic Innovatie & Interactie.

Holtz-Eakin, D., and C. Kao. 2003. "Entrepreneurship and Growth: The Proof is in the Productivity." Center for Policy Research, Paper 111. Syracuse, NY: Syracuse University.

Hsieh, C.-T., and P.J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, 124(4):1403–48.

IBGE (Instituto Brasileiro de Geografia e Estatística). 2005. Pesquisa de Inovação Tecnológica 2005.

INDEC (Instituto Nacional de Estadística y Censos de la República Argentina). 2003. Segunda Encuesta Nacional de Innovación y Conducta Tecnológica de las Empresas (1998-2001)

INE (Instituto Nacional de Estadística). 2008. Resultados de la Cuarta Encuesta de Innovación Tecnológica 2005, Consejo de Innovación de Chile / Instituto Nacional de Estadísticas -INE. Chile.

IDB (Inter-American Development Bank). 2010. "Science, Technology, and Innovation in Latin America and the Caribbean: A Statistical Compendium of Indicators." Washington, DC: IDB.

———. 2013. "Social Innovation: The Experience of the IDB's Innovation Lab." Washington, DC: IDB.

ITAM. 2012. "Evaluación de Impacto del Programa para el Desarrollo de la Industria del Software (PROSOFT)." Mexico City, Mexico: Instituto Tecnológico Autónomo de México (ITAM). Available at: http://www.prosoft.economia.gob.mx/Imagenes/ImagenesMaster/Estudios%20Prosoft/GREF_16.pdf.

Jaffe, A.B., and J. Lerner. 2007. *Innovation and its Discontents.* Princeton, NJ: Princeton University Press, pp.142–50.

Jaffe, A.B. 2013. "Science and Innovation Policy for New Zealand." *New Zealand Science Review*, 70(3):55–61.

———. 2000. "The U.S. Patent System in Transition: Policy Innovation and the Innovation Process." *Research Policy*, 29:531–57.

Johnson, C. 1982. *MITI and the Japanese Miracle.* Stanford, CA: Stanford University Press.

Kane, T.J. 2010. "The Importance of Startups in Job Creation and Job Destruction." Kauffman Foundation Research Series: Firm Formation and Economic Growth. Kansas City, MO: Ewing Marion Kauffman Foundation. Available at: http://ssrn.com/abstract=1646934.

Katz, J.M. 2001. *Structural Reforms, Productivity, and Technological Change in Latin America*. Santiago, Chile: ECLAC.

Kim, L. 1997. *Imitation to Innovations: The Dynamics of Korea's Technological Learning*. Boston, MA: Harvard Business School Press.

———. 1998. "Crisis Construction and Organizational Learning: Dynamics of Capability Building in Catching-up at Hyundai Motors." *Organization Science*, 9(4):506–21.

Kim, L., and R. Nelson. 2000. "Technology, Learning, and Innovation: Experience of Newly Industrializing Economies." Cambridge, England: Cambridge University Press.

Kline, S.J., and N. Rosenberg. 1986. "An Overview of Innovation." In R. Landau and N. Rosenberg, editors, *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington, DC: National Academy Press, pp. 275–305.

Klette, J., J. Moen, and Z. Griliches. 2009. "Do Subsidies to Commercial R&D Reduce Market Failures? Microeconomic Evaluation Studies." *Research Policy*, 29:471–95.

Lach, S., A. Bartel, and N. Sicherman. 2005. "Outsourcing and Technological Change." Working Paper 11158. Cambridge, MA: NBER.

Lederman, D., and W. Maloney. 2003. "R&D and Development." World Bank Policy Research Working Paper No. 3024. Washington, DC: The World Bank. Available at: http://ssrn.com/abstract=402480.

Lee, K. 2013. "How Can Korea Be a Role Model for Catch-Up Development? A Capability-Based View." In A.K. Fosu, editor, *Achieving Development Success: Strategies and Lessons from the Developing World*. Oxford, United Kingdom: Oxford University Press.

Lengyel, M. 2009. "La co-producción de la innovación y su diseño institucional: Evidencia de la Industria Argentina." Latin American and Caribbean Research Network. Washington, DC: IDB.

Lerner, J. 2009. *Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed — and What to Do About It*. Princeton, NJ: Princeton University Press.

———. 2012. "The Architecture of Innovation: The Economics of Creative Organizations." Boston, MA: Harvard Business School Publishing Coorporation.

Lerner, J., A. Leamon, and S. García-Robles. 2013. *Best Practices in Creating a Venture Capital Ecosystem*. Washington, DC: Multilateral Investment Fund (FOMIN), IDB.

López, A. 2009. "Las evaluaciones de programas públicos de apoyo al fomento y desarrollo de la tecnología y la innovación en el sector productivo en América Latina: Una revisión crítica." Innovation Note. Washington, DC: IDB.

López, A., A.M. Reynoso, and M. Rossi. 2010. "Impact Evaluation of a Program of Public Funding of Private Innovation Activities: An Econometric Study of FONTAR in Argentina." OVE Working Paper. Washington, DC: IDB.

Lozano-Ascencio, F., and L. Gandini. 2012. "Skilled-Worker Mobility and Development in Latin America and the Caribbean: Between Brain Drain and Brain Waste." *Journal of the Office of Latino/Latin-American Studies*, 4(1):7–26.

Lundvall, B. 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London, UK: Pinter.

Maloney, W., and A. Rodríguez-Clare. 2007. "Innovation Shortfalls." *Review of Development Economics*, 11(4): 665–84.

Martínez, J., M.V. Cano, and M. Soffia. 2014. "Tendencias y patrones de la migración latinoamericana y caribeña hacia 2010 y desafíos para una agenda regional." Population and Development Series No. 109. Santiago, Chile: ECLAC.

McKinsey Global Institute. 2014. "Global Flows in a Digital Age." McKinsey & Company. Accessible at: http://www.mckinsey.com/insights/globalization/global_flows_in_a_digital_age.

Metcalfe, S. 1995. "The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives." In P. Stoneman, editor, *Handbook of the Economics of Innovation and Technological Change.* Oxford, UK: Blackwell.

MICITT. 2008. "Indicadores nacionales de ciencia, tecnología e innovación: indicadores nacionales 2006–2007." San José, Costa Rica: Ministry of Science, Technology, and Telecommunications.

Navarro, J.C., J.J. Llisterri, and P. Zuñiga. 2010. "The Importance of Ideas: Innovation and Productivity in Latin America." In C. Pagés, editor, *The Age of Productivity.* Washington, DC: IDB.

Navarro, J.C., and A. Artopoulos. Forthcoming. "La política de la política pública en ciencia, tecnología e innovación en América Latina: modelo conceptual y casos estilizados." Washington, DC: IDB.

Navarro, J.C., and F. Vargas. Forthcoming. "La colaboración Industria-Universidad en Latinoamérica: sus efectos sobre la innovación y la productividad." Washington, DC: IDB.

Navarro, L. 2014. "Entrepreneurship Policy and Firm Performance: Chile's CORFO Seed Capital Program." Policy Brief. Washington, DC: IDB.

Nelson, R. 1959. "The Simple Economics of Basic Scientific Research." *Journal of Political Economy,* 67:297–306.

Nelson, R., and H. Pack. 1999. "The Asian Miracle and Modern Growth Theory." *The Economic Journal*, 109(457):416–36.

Nickell, S.J. 1996. "Competition and Corporate Performance." *Journal of Political Economy*, 104:724–46.

Observario Colombiano de Ciencia y Tecnología. 2013. "*Colciencias cuarenta años: Entre la legitimidad, la normatividad y la práctica*." Bogotá, Colombia: National University of Colombia and University of Rosario.

OECD and Eurostat. 2005. *Oslo Manual. The Measurement of Scientific and Technological Activities. Guidelines for Collecting and Interpreting Innovation Data, 3rd edition.* Paris, France: OECD and Eurostat.

OECD. 2005. *Innovation Policy and Performance: A Cross-Country Comparison*. Paris, France: OECD.

———. 2006. *Innovation and Knowledge-Intensive Service Activities*. Paris, France: OECD.

———. 2007. "Chile." OECD Reviews of Innovation Policy. Paris, France: OECD.

———. 2009a. "Mexico." OECD Reviews of Innovation Policy. Paris, France: OECD.

———. 2009b. "Korea." OECD Reviews of Innovation Policy. Paris, France: OECD.

———. 2009c. *Innovation in Firms: A Microeconomic Perspective*. Paris, France: OECD.

———. 2011. "Peru." OECD Reviews of Innovation Policy. Paris, France: OECD.

———. 2013a. *Latin American Economic Outlook 2013: SME Policies for Structural Change*. Paris, France: OECD.

———. 2013b. OECD Territorial Reviews: Antofagasta, Chile 2013. Paris, France: OECD. http://dx.doi.org/10.1787/9789264203914-en

———. 2014. "Colombia." OECD Reviews of Innovation Policy. Paris, France: OECD.

OECD MSTI. Main Science and Technology Indicators online database. Paris, France: OECD. Available at: http://www.oecd.org/sti/msti.htm.

OVE. 2013. "Second Independent Evaluation of the Multilateral Investment Fund." Washington, DC: OVE, IDB.

ORP. 2011. "Fondo para la Economía del Conocimiento: Informe de Progreso." Washington, DC: Office of Outreach and Partnerships (ORP), IDB.

Pagés, C., ed. 2010. "The Age of Productivity: Transforming Economies from the Bottom Up." *Development in the Americas*. Washington, DC: IDB and Palgrave-Macmillan.

Parra Torrado, M. 2011. "Exenciones fiscales para la I+D+i: experiencias en América Latina y retos pendientes." Discussion Paper No. 247. Washington, DC: IDB.

Perez, C. 2008. "A Vision for Latin America: A Resource-based Strategy for Technological Dynamism and Social Inclusion." Presented to the ECLAC Program on Technology Policy and Development in Latin America.

Popp, D., and R. Newell. 2009. "Where Does Energy R&D Come From? Examining Crowding Out from Environmentally Friendly R&D." Working Paper 15423. Cambridge, MA: NBER.

Rabellotti, R. Forthcoming. “Clusters in the Caribbean: Understanding their Characteristics, Defining Policies for their Development.” Technical Note. Washington, DC: IDB.

RAND Corporation. 2007. “The Global Technology Revolution 2020, In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications.” Santa Monica, CA: RAND Corporation.

RICYT. 2014. Database of Indicators. Buenos Aires, Argentina: Network of Science and Technology Indicators (*Red de Indicadores de Ciencia y Tecnología*, RICYT). Available at: http://www.ricyt.edu.ar.

Rivas, Gerardo. 2010. “Evaluación Intermedia del Programa de Ciencia y Tecnología del Perú.” Lima, Peru: InnovosGroup.

Rivas, Gonzalo. 2010. “How and When to Intervene? Criteria to Guide Interventions to Support Productive Development.” Technical Note. Washington, DC: IDB.

Rivas, G., and S. Rovira, editors. 2014. “Nuevas Instituciones para la Innovación: Prácticas y Experiencias en América Latina.” Santiago, Chile: ECLAC.

Rogers, E. 2003. *Diffusion of Innovations.* Fifth Edition. New York, NY: Free Press.

Romer, P. 1990. “Endogenous Technological Change.” *Journal of Political Economy*, 98:S71–S102.

Rostow, W. 1960. *The Stages of Economic Growth.* Cambridge, UK: Cambridge University Press.

Rouvinen, P. 2002. “Characteristics of Product and Process Innovators: Some Evidence Forms the Finnish Innovation Survey.” *Applied Economics Letters*, 9(9):575–80.

Rubalcaba, L. 2007. *The New Service Economy: Challenges and Policy Implications for Europe*. Gloucestershire, UK: Edward Elgar Publishing.

Saenz-Arce, P., and J. Uquillas. 2005. “Search and Innovate: A Way Towards Technology Change in Small Countries.” Economic and Sector Study Series. Washington, DC: IDB.

Sagasti, F. 2011. “Ciencia, tecnología, innovación: políticas para América Latina.” Lima, Peru: Economic Culture Fund.

Savona, M., and W.E. Steinmueller. 2013. “Service Output, Innovation and Productivity: A Time-based Conceptual Framework.” *Structural Change and Economic Dynamics*, 27:118–32.

Schmidt, K.M. 1997. "Managerial Incentives and Product Market Competition." *Review of Economic Studies*, 64:191–214.

Schmutzler, A. 2009. "Is Competition Good for Innovation? A Simple Approach to an Unresolved Question." *Foundations and Trends in Microeconomics*, 5(6):355–428.

———. 2013. "Competition and Investment: A Unified Approach." *International Journal of Industrial Organization*, 31(5):477–87.

SCImago. 2014. SJR — SCImago Journal & Country Rank. Retrieved August 07, 2014, from http://www.scimagojr.com.

SENACYT. 2009. "Encuesta sobre Investigación, Desarrollo e Innovación al Sector Privado: Año 2008." Panamá: National Secretariat for Science, Technology and Innovation (*Secretaría Nacional de Ciencia, Tecnología e Innovación*, or SENACYT).

Shane, S. 2009. "Why Encouraging More People to Become Entrepreneurs Is Bad Public Policy." *Small Business Economics*, 33:141–49.

Soete, L., B. Verspagen, and B. Ter Weel. 2010. "Systems of Innovation." In: B.H. Hall and N. Rosenberg, editors, *The Economics of Innovation*. Amsterdam: North Holland.

Solow, R.M. 1957. "Technical Change and the Aggregate Production Function." *The Review of Economics and Statistics*, 39(3):312–20.

Spence, M. 2010. "Some Thoughts on ICT and Growth."*Information Technology and International Development*. 6, SE: 6-9.

Stein, E., and R. Wagner. 2013. "Venture Capital in Latin America: A Comparative Perspective." Presented in Séptima Conferencia sobre Microevidencia en Innovación y Desarrollo Económico, Santiago de Chile, November 7-8.

Steinmueller, E. 2010. "Economics of Technology Policy." In: B. H. Hall and N. Rosenberg, editors. *The Economics of Innovation*. Amsterdam: North Holland.

Stenholm, P., Z. Acs, and R. Wuebker. 2013. "Exploring Country-Level Institutional Arrangements on the Rate and Type of Entrepreneurial Activity." *Journal of Business Venturing*, 28(1):176–93.

Stevens, P. 2003. "Resource Impact: Curse or Blessing? A Literature Survey." *Journal of Energy Literature*, 9(1):3–42.

Stiglitz, J., and A. Weiss. 1981. "Credit Rationing in Markets with Imperfect Information." *American Economic Review*, 71(3):393–410.

Tacsir, E. 2011. "Innovation in Services: The Hard Case for Latin America and the Caribbean." Discussion Paper No. 203. Washington, DC: IDB.

UNCTAD. 2011a. "Science, Technology, and Innovation Policy Review: El Salvador." Switzerland: United Nations Conference on Trade and Development (UNCTAD).

———. 2011b. "Science, Technology, and Innovation Policy Review: Peru." Switzerland: UNCTAD.

———. 2012. "Science, Technology and Innovation Policy Review: Dominican Republic." Switzerland: UNCTAD.

UNESCO. Institute for Statistics. Paris, France: United Nations Educational, Scientific and Cultural Organization (UNESCO). Accessed July 2014. Available at: http://data.uis.unesco.org/

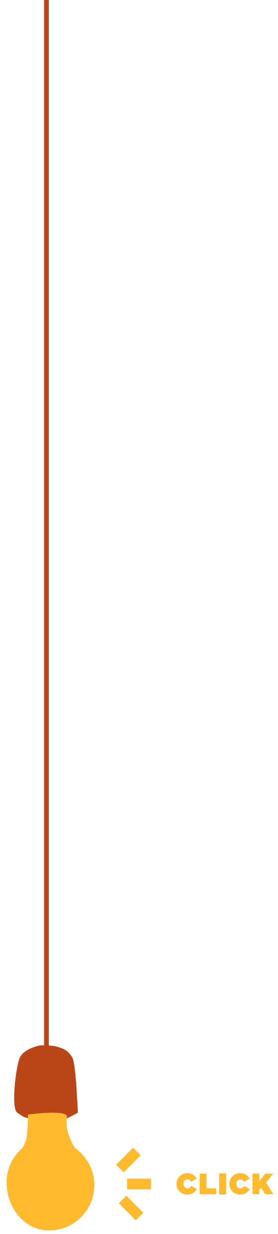
Ventura, J.P. 2010. "Análisis de Capacidades Institucionales de Organismos de Ciencia y Tecnología en América Latina y el Caribe." Washington, DC: IDB.

Vives, X. 2008. "Innovation and Competitive Pressure." *Journal of Industrial Economics*, 56:419–69.

Volpe Martincus, C., and J. Carballo. 2010. "Beyond the Average Effects: The Distributional Impacts of Export Promotion Programs in Developing Countries." Working Paper Series No. 204. Washington, DC: IDB.

Wagner, R., and E. Stein. 2014. "The Start-Up and Scale-Up of High-Productivity Firms." In Crespi, Fernández-Arias, and Stein, editors, *Development in the Americas: Rethinking Productive Development: Sound Policies and Institutions for Economic Transformation.* Washington, DC: IDB and Palgrave-Macmillan.

WIPO. Geneva: Switzerland. World Intellectual Property Rights Organization. Accessed July 2014. Available at: http://www.wipo.int/patentscope/en/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