

INNOVATION, SCIENCE, AND TECHNOLOGY SECTOR FRAMEWORK DOCUMENT

COMPETITIVENESS, TECHNOLOGY, AND INNOVATION DIVISION

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ABBREVIATIONS

BIM	Building Information Modeling
BNDES	Brazilian Economic and Social Development Bank
CDTI	Centro para el Desarrollo de Tecnología Industrial [Center for the Development of Industrial Technology]
FONDEF	Fondo de Fomento al Desarrollo Científico y Tecnológico [Fund to Promote Scientific and Technological Development]
FONTAR	Fondo Tecnológico Argentino [Argentine Technology Fund]
FONTEC	Fondo de Desarrollo Tecnológico y Productivo [Technological and Productive Development Fund]
FSE	Fondo Sectorial de Energía [Energy Sector Fund]
GDP	Gross domestic product
GVC	Government-sponsored venture capitalists
LAC	Latin America and the Caribbean
MSTI	Main Science and Technology Indicators
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
R&D	Research and development
RICYT	Red de Indicadores de Ciencia y Tecnología [Network for Science and Technology Indicators]
SFD	Sector Framework Document
SMEs	Small and medium-sized enterprises
STI	Science, technology, and innovation

EXECUTIVE SUMMARY

INNOVATION, SCIENCE, AND TECHNOLOGY SECTOR FRAMEWORK DOCUMENT

The Innovation, Science, and Technology Sector Framework Document (SFD) reflects new issues and perspectives drawn from advances in research and in the practice of designing and executing development projects in the sector.

This document is based on the notion that innovation and its related activities, such as science and technology, are essential tools for boosting competitiveness, contending with the challenges posed by climate change, and improving the standard of living for the region's citizens. It is by introducing new products, enhancing production processes, and having new ways of structuring business—known as innovation—that productivity gains are made in the sectors and countries in the region. Likewise, improvements in job quality, income distribution, mitigation of and adaptation to the effects of climate change, and the inclusion of talent and creativity are causes and effects of having more innovative economies and societies. Innovation, understood to be a process, draws on multiple key factors, including people, knowledge and infrastructure, which are concepts related to science and technology.

Recognizing that science, technology, and innovation (STI) have a pervasive and growing presence in all human activity, and hence are a crosscutting issue, this SFD focuses on a particular but important aspect of innovation: governments playing an essential role by directly fostering innovation, establishing an enabling environment for technology-based entrepreneurship and innovation, and providing complementary public goods such as scientific knowledge and advanced human development. The virtuous combination of scientific, technological, regulatory, and connectivity pre-conditions, which constitute a national innovation system, is also a key part of innovation addressed in this document.

The private sector is central to driving innovation activity, but a number of factors explained in this document show that it may not produce the socially optimal level of innovation if left to its own devices. In this context, policies and programs that address market and coordination failures and support the development of national innovation systems are key. The ultimate goal of public policy in this sector is to enhance business productivity and competitiveness in the Latin American and Caribbean 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 of scientific, technological, regulatory and connectivity preconditions of such enhancement is also a key part of what the Inter-American Development Bank (IDB) and IDB Invest do and this document covers. The IDB Group, as a whole, has singled out innovation as a focus for action, to narrow the productivity gap in all countries in the region.

This document is divided into five sections. Section I defines the theme and scope of the SFD and how it is linked to the IDB Group's strategy. Section II defines innovation as the transformation of new ideas into economic and social solutions, i.e. ones that add value. It then characterizes the countries in the region in the various dimensions of innovation that occurs in companies and productive sectors and in the main activities that drive it. A general diagnostic assessment is performed based on that analysis, which shows that innovation in the region is low, and three dimensions are proposed to address that situation. First, it posits that the incentives for companies in the region to innovate are weak, primarily because the competitive pressure this requires is absent. This would be particularly relevant for larger companies in relatively small markets. Second, governments in the region underinvest in key government actions as inputs for innovation,

such as infrastructure, financing basic and applied knowledge, advanced human capital and expertise, and provide weak demand for innovation. Likewise, it suggests that weak innovation in the private sector is due to inherent market failures in innovation activities. Here, governments are not offering sufficient responses to overcome knowledge spillovers, labor and capital market failures, appropriability problems, and the intangibility of assets, among other things. Third, the government institutional framework needed to strengthen and coordinate STI activities in the countries is weak.

Section III analyzes the policy objectives stemming from the foregoing diagnostic assessment. In that connection, it reviews both international and regional experience with tools and mechanisms aimed at attaining those policy objectives. The document proposes a classification for those tools that is consistent with the three areas described above and also highlights potential problems and requirements for them to function properly, together with any evidence on its effects and impact. The latter is used to determine knowledge gaps and areas driving a future research agenda on those topics.

Section IV synthesizes the Bank's work on evaluation of STI projects—which generally tells a story of successful policy interventions—and summarizes the main lessons learned from IDB Group activities in the sector, commenting on the strengths the Bank has as a provider of financing and technical assistance in STI policy and IDB Invest has with its financial services and products and its advisory services for the private sector.

Lastly, based on the preceding chapters, Section V proposes six lines of action needed to address the gaps identified, bearing in the mind the diversity that exists in the area of innovation among the countries in the region. These lines of action include increasing investment in public goods for innovation, fostering an enabling environment for private investment in innovation, promoting actions to address market failures that limit business innovation, strengthening key institutions to promote innovation, and a knowledge agenda that makes it possible to close the gaps and provide grounds for IDB Group support for these activities in the countries of the region.

I. THE INNOVATION, SCIENCE, AND TECHNOLOGY SECTOR FRAMEWORK DOCUMENT IN THE CONTEXT OF CURRENT REGULATIONS, THE INSTITUTIONAL STRATEGY, AND INTERNATIONAL AGREEMENTS

- 1.1 The document “Strategies, Policies, Sector Frameworks and Guidelines at the IDB” (document GN-2670-5) established that Sector Framework Documents (SFDs) should “provide flexible guidance to accommodate the diversity of challenges and institutional contexts faced by the Bank’s 26 borrowing member countries, and at the same time should be narrow enough to provide meaningful guidance to IDB Group specialists and provide a clear sense of the challenges the Bank seeks to address in a given sector.” In keeping with this mandate, the Bank adopted the Innovation, Science and Technology SFD in 2014. This updated version reflects new issues and perspectives drawn from advances in research and in the practice of designing and executing development projects in the sector and replaces document GN-2791-8.
- 1.2 The IDB Group as a whole has singled out innovation as a focus for actions, so this Innovation, Science, and Technology Sector Framework Document is consistent with the second Update to the Institutional Strategy 2020-2023 (document AB-3190-2), particularly in the development and implementation of instruments that promote innovation in the countries of the region.^{1, 2} This SFD is also consistent with the Sector Strategy Institutions for Growth and Social Welfare (document GN-2587-2), which responds to the call in the Ninth Capital Increase to focus on strengthening private sector entities such as small and medium-sized enterprises (SMEs) by bolstering public institutions. The strategy highlights the role of innovation and technological development institutions in fostering increased SME competitiveness and private sector growth. It also describes the need to build innovation capacity, increase access to technology, and improve linkages among the key actors in the innovation system in order to upgrade firm performance and productivity levels.
- 1.3 By nature, the science, technology, and innovation (STI) sector is crosscutting and so elements of the sector appear in all of the different sector strategies. As a result, the framework set forth in this SFD is expected to support innovation, research and technology-related priorities and concerns that are found across those strategies. Accordingly, it bears in mind the recommendations and commitments stemming from the IDB Group Climate Change Action Plan 2021–2025 (document GN-2848-9). Likewise, inasmuch as this SFD touches upon the needs of SMEs in Latin America and the Caribbean (LAC) and the respective policy responses, it also complements the Support to SMEs and Financial Access/Supervision SFD (document GN-2768-7). The same is true regarding the competition policies set forth in the Integration and Trade SFD (document GN-2715-11).

¹ Sections 3.10 to 3.12 and 4.3(iii) of the Strategy.

² All operations involving innovation, science, and technology, which will fall under this SFD, must comply with Bank policies on safeguards (operational policies OP-102, OP-703, OP-704, OP-710, and OP-765), including those related to financial intermediation to finance private sector projects.

- 1.4 STI have a pervasive presence in all human activity. Many sectors in which the IDB Group works in Latin America and the Caribbean are expected to incorporate innovation and technology as a growing part of their programs; energy production and consumption, water and sanitation, environmental protection, agricultural production, transportation, commerce, telecommunications, the media, public administration, transparency, tax collection and administration, education, health care and social policy constitute just a partial list. Cross-sectoral issues such as climate change, digital transformation, or gender and diversity are also closely linked with innovation and technological challenges and opportunities. This reflects well established worldwide trends toward increasing knowledge and innovation density in national economies.
- 1.5 This SFD focuses on a particular but important aspect of innovation. It recognizes that governments in borrowing member countries play a critical role in enhancing competitiveness by directly encouraging business innovation, establishing an enabling environment for firm innovation and technology-based entrepreneurship, and providing complementary public goods such as scientific knowledge and advanced human capital. As regards the latter, it is consistent with the Skills Development Sector Framework Document (document GN-3012-3). The ultimate goal of public policy in this sector is thus to enhance business productivity and competitiveness in Latin American and Caribbean companies by facilitating the creation and growth of dynamic firms with the capacities and tools to innovate and compete in international markets. So too is promoting inclusive, sustainable development and economic growth. Putting together the architecture of scientific, technological, regulatory and connectivity preconditions of such enhancement is also a key part of what the IDB Group does.³ This focus on private sector innovation and productivity, as well as on the public policies aimed at enhancing it, leaves the topic of innovation in the public sector beyond the scope of this SFD. Even though there are points in which the two fields connect, public sector innovation is a complex matter that deserves specialized treatment that cannot be reduced to the simple extension of firm innovation.⁴ Other SFDs address the topic further.⁵ This document is also aligned with the new Environmental and Social Policy Framework (document GN-2965-23) inasmuch as it recognizes the importance of implementing sound environmental and social risk management standards in innovation instruments.

³ 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 (2005), 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.'"

⁴ Annex V of the document on Strategies, Policies, Sector Frameworks and Guidelines at the IDB (document GN-2670-5) states that public innovation is outside of the scope of the Innovation, Science, and Technology Sector Framework Document.

⁵ See the Housing and Urban Development Sector Framework Document (document GN-2732-11), the Decentralization and Subnational Governments Sector Framework Document (document GN-2813-8), and the Citizen Security and Justice Sector Framework Document (document GN-2771-7).

- 1.6 This SFD provides insight as to international best practices, and it highlights specific examples from the region regarding policy and program design and implementation in the sector. It embraces the larger challenges, such as the United Nations Sustainable Development Goals, particularly those related to industry; innovation and infrastructure; climate action; gender equality; decent work and economic growth; and responsible consumption and production.

II. INNOVATION, SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT, AND THE SUSTAINABILITY OF ECONOMIC GROWTH

A. Introduction

- 2.1 **Context.** The recent pandemic has unleashed one of the largest crises in memory in the last 100 years across the globe. This crisis, stemming from the emergence and rapid spread of the SARS-CoV-2 virus, or COVID-19, has had an enormous impact on everyone's quality of life. As a result of lockdowns, social distancing, and other measures to mitigate the effects of the virus on people's health, today the world is seeing the main economic and social indicators roll back significantly. This phenomenon has occurred in all countries and regions but has been particularly severe in lower-income geographic areas and those with less prepared health systems and lower levels of social protection. The hardest hit areas—besides health—include sharp drops in employment, reduced investment, and the failure of companies, particularly smaller ones, all of which severely impact economic growth indicators. Similarly, there have been setbacks in various dimensions of development, such as job quality, income distribution, forced migration, and overall quality of life of the population. Although today some indicators are improving, albeit concentrated in high-income countries, the region still faces major challenges to achieving a vigorous recovery in health and in productive and social dimensions.
- 2.2 **Relevance of science, technology, and innovation (STI) in the response.** Reviewing recent pandemic-related developments reveals that one of the main responses to regain part of the ground lost and ensure a better quality of life for the population has come from STI (IDB, 2020). Indeed, today it would be unthinkable to envision a recovery without a broad set of vaccines specifically designed to counter the effects of the virus. The response in terms of developing, piloting, implementing different phases of testing, and producing vaccines has been substantially faster than in the past. In addition, development locally of mechanical ventilation equipment and diagnostic devices has shown how technological development can offer rapid, concrete responses to problems afflicting much of society. Lastly, restrictions on movement and the inability to access many products and services in person has driven the development of major innovations in platform-based services and digital solutions. In addition, it should be noted that the countries that have made the most progress in incorporating digital tools and solutions have fared best in the pandemic in a variety of areas, including monitoring individuals, vaccine distribution, medical care, working from home, remote schooling, digital public services, economic recovery, and digital transformation in companies. STI tools have been key in this process (IDB, 2020).
- 2.3 **Crisis exposes the status of STI in the region.** The pandemic has exposed the region's shortfalls in STI. Past responses have been quite varied, given the major differences in the countries' scientific, technological, and innovation capacities.

History has shown that crises are also windows of opportunity. In fact, major advances in STI have been triggered by profound crises, forcing us to rethink and redesign how to deliver solutions and respond to problems that have arisen during difficult times. Health is one area, but the current climate crisis, heightened social tensions, and the need for greater connectivity are also areas in which an STI-based response can deliver technically and economically viable solutions.

- 2.4 **Collective responses.** These responses have come from different parts of the productive and social structure: from the knowledge gains made in university laboratories; from entrepreneurs' work to develop responses to old and new challenges alike; from established companies that champion providing innovative value propositions addressing new demands from consumers as well as the hopes and concerns of society that crises reveal. These responses also come from the public sector, on the one hand establishing the conditions for the private sector to operate better and, on the other, by financing a broad range of activities where market incentives are not strong enough or by directly providing some public goods needed for technological and innovation activities to flourish, and sometimes coordinating efforts among all of these actors for a common good.
- 2.5 **STI beyond cyclical factors: growth and development.** STI-based responses are not only necessary for addressing needs stemming from a crisis like the one we are experiencing. The following section shows how theory and evidence suggest that STI activities are essential for boosting productivity and, thereby, enhancing countries' growth. This occurs by introducing new products and improving processes, as well as enhancing how companies organize for delivering their services. There is also resounding evidence of the effect innovation activities have on job quality, better wages, income distribution, more sophisticated production, and export diversification. STI activities are also key for meeting collective challenges, such as an aging population and inequalities and social exclusion, or to fulfill countries' commitments, such as decarbonization commitments under the Paris Agreement.
- 2.6 The next section explains the basic concept of innovation and the connections between STI and economic growth and development. It then reviews the situation in the region, based on different indicators of the efforts and results of STI activities in the countries of the region, and presents a diagnostic assessment of the situation. Lastly, the chapter closes by raising three major challenges stemming from that assessment.

B. Innovation and knowledge—Keys to productivity growth and economic development

- 2.7 **Definition.** Innovation is the transformation of new ideas into economic and social solutions. Innovation can be: a new or significantly improved product (good or service) or production process, such as a new marketing practice or a new organizational method in business practices, workplace organization or external relations (Organisation for Economic Co-operation and Development—OECD/Eurostat, Oslo Manual, 2018). It should be noted that the innovation merit could be new to the world, to the national market, or to the firm. This document considers all three, since aspects of frontier innovation, international transfer of technology, and adoption of existing technology in firms (or dissemination) are of interest.

- 2.8 **Innovation as a process.** Innovation is a systemic process involving countless activities. On the one hand, it encompasses the activities necessary to establish **technical feasibility** for producing a new product, improving a production process, or providing a new service. On the other, once technical feasibility is resolved, it includes all the necessary activities to make the proposal attractive to users, consumers, or citizens. That is to say, the activities needed to determine the **value feasibility** (when a proposal is attractive and valuable to persons or agents other than those that produced it).
- 2.9 **Two stages of innovation.** Stage one includes all activities based on scientific, technological, and engineering development and production experience that makes it possible to turn an idea into a prototype with the potential to create value for a third party. These prototypes can sometimes have intellectual property protection through patents, design protection, and/or copyright.⁶ Stage two includes all activities for turning a technical proposal into one that creates value for the user. The latter activities include scaling, packaging, transfer, supporting adaptation and use, sale, and postsale support. These activities require work in science and technology, but unlike the former, they are more intensive in human capital and physical investment, process engineering, and tools for sale and postsale support. Once again, it is the user or beneficiary of an innovation proposal who determines whether it is valuable, not the producer of that proposal.
- 2.10 **Firms as innovation agents.** In this arrangement, firms are the main producers of innovations, and depending on their size, activity or productive sector, they could carry out both stages.⁷ The firm may already be established or still being formed to develop innovations, in which case they are called innovative ventures. Pavitt (1984) suggests that pharmaceutical or machinery sectors in fact carry out both activities, as their firms have large research and development (R&D) units. Conversely, commodity production sectors, where the advantages come from developing process innovations aimed at cutting costs, specialize in the second stage, leaving the first to other specialized providers or to universities and applied research centers.⁸
- 2.11 **Inputs for innovation.** Different inputs feed innovation. First, there are ideas—not just the ones needed to develop technically feasible proposals but also those aimed at offering value to consumers or users. Second are the people who perform these activities, either in universities creating knowledge that can then be used to develop innovations, people in the firms directly involved in turning those ideas into feasible prototypes, and those charged with ensuring that inventions, prototypes, and creations with potential value reach end users or consumers of those proposals, thereby turning them into innovations. One relevant input for doing all of this work is infrastructure. That includes not only labs, physical spaces, and offices where R&D work is done, but also all the digital and other intangible infrastructure needed to turn ideas into innovations. It also includes the

⁶ One way of characterizing the different stages of this technical validation is set out in the Technology Readiness Levels (TRL). See https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf.

⁷ Clearly, there are specific elements beyond the productive sector that can drive the decision whether or not to carry out one or two of these stages (or none). History, culture, experience, and lessons learned can also influence that decision.

⁸ This arrangement can be applied to other agents that produce innovations, such as the public sector or socially oriented institutions. The former are known as public innovations and the latter as social innovations.

investments needed for conducting pilots, proofs of concept, scaling up, and packaging to bring potential innovations to the final markets. All of this also requires financial resources. In the context of innovation activities, these resources are used to pay salaries, make the necessary investments, gain knowledge and tailor it to local conditions, and finance the mechanisms needed to introduce the innovations in national and internal markets.

- 2.12 **Innovation, productivity, and growth.** Innovation is a key determinant of long-term growth by improving the ways in which capital and labor combine and consequently boosting the yields from the same level of productive factors. That is to say, productivity gains, the introduction of new products and services, and/or better production methods affect the economic performance of firms, productive sectors, and countries. As [Figure 1](#) shows, productivity in the region has been losing relative ground in recent decades, consistent with low levels of STI work in the region.⁹ Generally speaking, investment in innovation is a critical factor in long-term growth, not a result of that growth.¹⁰ Previous research also found that R&D accounts for up to 75% of the differences in total factor productivity growth rates, once externalities are taken into consideration (Griliches, 1979) where about half of the variation in income levels and growth rates among countries is due to differences in total factor productivity (Hall and Jones, 1999).
- 2.13 **Return on innovation.** Different studies suggest that both at the country level (Lederman and Maloney, 2003) and at the production plant level (Goto and Suzuki, 1989) investment in innovation has a considerable, significant return. The figures show that this return (private) can be over 30%—more than double the average return on physical capital, although the same research suggests that these investments have a higher level of risk related to technological and commercial uncertainty (Van Reenen, 1997). It should be noted that these same studies warn that these returns are expressed over a longer period than traditional investments, since they are intangible and also incur adaptation and learning costs in order for those returns to materialize (Benavente, 2005).
- 2.14 **Social return.** Social returns on investment in innovation tend to be even higher than private returns, wherever there are spillovers associated with the knowledge that cannot be fully captured by those who invest in its development. For more developed economies, social rates of return on R&D have been estimated at 40% or more (Hall, Mairesse, and Mohnen, 2009). Innovation activities, particularly R&D investment, are fundamental for the development of new competencies and skills

⁹ The endogenous growth literature has closely linked countries' efforts to invest in ideas and those ideas becoming new intermediate products (machinery and equipment) or final goods and services, and in improved growth, both in terms of level and trend (Lucas 1989, Romer 1990, Aghion and Howitt, 1992). The evidence supports this link that investment in R&D leads to productivity growth, not the other way around (Rouvinen, 2002). The economic literature has generally focused on the effects of STI activities on productivity and growth, and to a lesser extent on development and prosperity (Christiansen, 2019).

¹⁰ 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). Moreover, the theoretical and empirical discussion is still open on the causality between STI and growth. Since Schumpeter, there has been mention of this dual causality. It is therefore assumed that it is the institutional structure that gives this feedback effect from growth to STI efforts. In the case of countries lagging farther "behind" in terms of distance from the global technological frontier, STI policies are different, concentrating on extensionism, transfer, and adoption. And the institutional structure needs to be ad hoc to this. Accordingly, the lessons learned emphasize that this is an evolving process and that policies must have these characteristics, depending on the specific situation of each country.

needed to seek, acquire, and adapt existing technology. In other words, innovation activity is a key driver of economic convergence (Rostow, 1960; Cohen and Levin, 1989).¹¹ In fact, advanced economies' returns on R&D investment tend to increase with distance from the technological frontier (Griffith et al., 2004).

- 2.15 **Returns in the region.** Social rates of return on innovation exhibit the same pattern in developing economies, and some estimates find them to be even higher (Benavente et al., 2005). Although initially, Lederman and Maloney (2003) found that the social returns on R&D averaged around 60% for medium-income countries, such as Mexico and Chile, and over 100% for lower-income countries, such as Nicaragua, later studies suggest that rates of return on R&D follow an inverted U pattern. This is attributed to the absence of a critical mass of complementary inputs for innovation—particularly in the technical feasibility stage—such as adequate human capital, weak scientific infrastructure, weak private sector development and sophistication and overall poor coordination and low complexity of the innovation system (Goñi and Maloney, 2017). Nevertheless, in the case of Chilean manufacturing, innovation has a private return of nearly 30%—almost double that of physical capital (18%) once corrected for risk (Benavente et al., 2005).
- 2.16 **Relevance of the digital world.** The digital revolution is highly relevant for the STI strategy, as in itself it can be considered a (radical) innovation. Information and communications technologies (ICT) serve as an enabling framework for driving innovation and productivity. In fact, an estimated average increase of 10% in broadband penetration in the countries in the region leads to a 3.2% jump in GDP and a 2.6% rise in productivity (García Zaballos and López-Rivas, 2012). Put another way, the obstacles to innovation in the region are the reasons why progress is flagging on the digital revolution, which involves the adoption of digital innovations.¹² The digital revolution can also be viewed as a revolution in the storage and exchange of information, which has a dramatic impact on the social returns on innovation, since ideas can be transmitted at lower cost, more quickly, and to larger audiences (IDB, 2017, 2021). Beyond the original possibilities created by the advent of personal computers and Internet connectivity in the last decade of the 20th century, the convergence of digital technologies such as machine learning, mobile devices, sensors, blockchain, artificial intelligence, and the Internet of Things has spearheaded innovations that are having powerful impacts across industries other than the ICT industry itself, leading to the notion of a new industrial revolution embodied in the digitalization of the whole economy.¹³

¹¹ The importance of knowledge and technological capabilities for economic convergence has been 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).

¹² A detailed and comparative perspective regarding the current state of broadband access in Latin American and Caribbean countries can be found in the Broadband Development Index built by the Bank (García Zaballos and Iglesias, 2017). Moreover, the IDB Group's 2021 Digital Transformation Action Framework provides evidence of the relative lag, as well as digital technologies' enabling effect on business and production activities.

¹³ The widespread impact of digital technology on different sectors and social activities around the world has been the subject of a series of reports (OECD, 2015; OECD, 2017; World Bank, 2016). A case analysis for the region is available in the IDB Group's Digital Transformation Action Framework (IDB, 2021).

C. Overview of innovation, science, and technology in the region

- 2.17 **Challenge with measuring.** Characterizing innovation and its related activities, such as work on science and technology, is no easy task. Generally, these efforts, at both the country and the sector/firm level, have been measured on the inputs side (OECD, 2015 Frascati). So, in general, the number of people and amount of financial resources needed to transform ideas into solutions (inventions, for example) are what is cited, sidestepping the technical feasibility stage. In this stage, outcomes tend to be measured by number of patents or other indicators related to intellectual property. In the value feasibility stage, it is even harder to measure. Firms' R&D costs and their investment in personnel, infrastructure, machinery, and equipment for scaling up the innovation and putting it to use are generally considered inputs in the second stage. The outcome of this second stage, at the firm level, is measured by the number of new products sold, the percentage of total sales this represents, or cost reductions from introducing process enhancements. These last indicators are harder to obtain and build, but some efforts have been made to that end (OECD/Eurostat, 2018), including in the countries in the region (Manual de Bogotá, 2001).¹⁴
- 2.18 **Research and development spending.** This is perhaps the best known measurement of countries' STI efforts. While it only measures innovation on the inputs side, and primarily the technical viability stage, as mentioned earlier, the theoretical and empirical literature suggests it has a significant effect on productivity. [Figure 2](#) shows this indicator for a broad range of countries.¹⁵ It illustrates the significant difference and shows that fast-growing countries like Israel and South Korea invest close to 10 times the average investment in the region. Adjusting for per capita income or another equivalent income measurement, countries like Chile, with income of over US\$24,000 per inhabitant, should invest over 1 point of GDP in this type of activity to be consistent with the average trend for OECD countries, although today it invests one-third that amount (Consejo Nacional de Innovación para la Competitividad de Chile-CNID, 2015).¹⁶ Another characteristic that emerges when looking at the differences between countries leading the way in STI and those in the region is the percentage of spending financed by the private sector. On average, close to 66% of R&D spending in OECD countries comes from private sources, while it is exactly the opposite for countries in the region (OECD Main Science and Technology Indicators (MSTI) 2020, Network for Science and Technology Indicators - RICYT, 2020).¹⁷
- 2.19 **Researchers.** The other production factor generally considered in comparisons of STI efforts is the number of researchers participating in the different stages of the

¹⁴ A breakdown of the progress and availability of information on STI in the majority of countries in the region is available in Crespi et al. (2021).

¹⁵ It should be noted that the figure does not present data from some countries in the region. That is because the information does not exist and/or is not comparable. Accordingly, part of the Bank's effort has been to support the countries in generating that information (Crespi et al., 2021).

¹⁶ Although this data point is from six years ago due to information problems, it is not expected to have changed in this time.

¹⁷ For natural resource-intensive developed countries, public participation is somewhat higher, particularly at the outset of R&D spending expansion phases (CNID, 2018).

innovation process.¹⁸ Here too the region appears to be well behind. As [Figure 3](#) shows, the region has two researchers per 1,000 people in the labor force, while the number is close to nine for OECD countries. What's more, when studying the time course on a horizon between 2010 and 2018, that ratio has even been declining over time in some countries like Uruguay, Mexico, and Bolivia, exhibiting little change when the region is examined at the aggregate level. With the exception of Finland, a radically opposite phenomenon is seen in OECD countries, where researchers have made up a growing share of the labor force over time. The statistics on gender balance ([Figure 3a](#)) show that, while the differences between the countries of the region and a group of developed countries are not large, there are gaps that, if closed, would improve not only justice but also efficiency and impact (Grazzi et al., 2019).

- 2.20 **Patents.** Patents are one way to measure the outcome of the technical feasibility stage. When looking at this indicator, presented in [Figure 4](#), the region appears to be well behind. Either measured as patent applications in the country of origin or as applications registered in the International Patent System (PCT), the OECD countries have more than 10 times the number of applications by universities, firms, or individuals than the region. This indicator is already adjusted for the size of the economy, so the issue is not that they are higher income countries, but rather that they do in fact produce many more patents than the countries in the region.¹⁹
- 2.21 **Innovation.** When reviewing the evidence on the outcome side of innovative activity, in both stages, the percentage represented by sales of new products or services out of firms' total sales does not reach 3% for countries like Chile or Colombia, while this indicator averages over 12% for OECD countries (see [Figure 5](#)). Moreover, for developed countries, a significant portion of those sales are of products that are new in the market where the firms operate; while for firms in the region, the majority are innovations that are new for the company but already exist in the local market. Similarly, when looking at the efforts firms make to develop innovations, in OECD countries much of these are associated with both intramural and extramural R&D spending, while in the region, spending on innovation is associated with purchasing machinery and equipment (see [Figure 6](#)).²⁰
- 2.22 **Shortfalls in the ecosystem.** Companies are the main agents for turning ideas into value propositions through innovation. However, this two-phase process does not happen in a vacuum, but rather through interaction with academia, suppliers, other companies, or clients and/or users. This collective process of innovation, which embodies the so-called National Innovation Systems (Lundvall, 1987) or Innovation Ecosystem, can affect the innovation speed, effectiveness, and performance of companies, productive sectors, and countries. The main systemic

¹⁸ Researchers are considered to be all workers involved in R&D and in innovation in firms and universities and other agents involved in STI activities. They include not only persons with a PhD or Master's degree but also engineers, specialists, and technicians directly involved in such work.

¹⁹ Clearly there is a high correlation between R&D efforts, the number of people working in STI activities, and the number of patents registered by the countries (IDB, 2014). As is the case with other indicators, the information is not reported for all countries in the region, either because it does not exist or because it is not comparable.

²⁰ Although this could be due to differences in the countries' productive structure, it should be noted that Finland and especially Norway have productive structures that are natural resource-intensive, similar to the majority of countries in the region.

obstacles include legal roadblocks and lack of confidence (social capital), among others. [Figure 7](#) shows that, although the level of cooperation among firms is similar in OECD countries and some countries in the region, the major difference is in international cooperation. This obviously characterizes how innovation emerges in the countries in the region. This is consistent with the indicators on the innovation environment proposed by the World Bank (Doing Business Report) or the World Economic Forum (Competitiveness Indexes, several years) where the countries in the region appear far behind the developed countries, in particular in areas relating to relationships with universities, with users, and with other firms in the sector.

- 2.23 **Support for innovation.** There is evidence (reviewed in the following section) that public support is crucial for helping to overcome the market failures that affect firms' level of innovation. With respect to the number of companies that receive public support for innovation, [Figure 8](#) shows that at least 1 in 10 companies receives such support in OECD countries, while that number falls to less than 2 in 100 for countries in the region.
- 2.24 **Political economy.** Alongside the foregoing indicators, it should be noted that, given the intangibility of many of the outcomes of innovation—particularly in its early stages—and the time it takes for those benefits to materialize in private and social returns, so-called failures of government arise that hinder greater private efforts, and particularly public efforts, to support such activities. Although further below this SFD illustrates how to address such failures of government, clearly in the region the lack of persistent efforts to promote innovation activities, together with the lack of clarity of who is responsible for that work, are a reflection of the political economy associated with that sector.
- 2.25 **Summary of the evidence.** A comprehensive overview of the indicators examined thus far suggests that innovation is low, as is the level of scientific and technological activities. Given the disparate conditions among the countries, all the indicators suggest that efforts by the private sector, public sector, and other agents involved in innovation, such as universities, technical training centers, foreign companies, and scientific groups, are falling short of the region's development standards. And this raises the major question of what can be done, and how, to close these gaps. To that end, below is a general diagnostic assessment divided into three complementary pillars, where companies are at the heart of the innovation process.
- 2.26 **General diagnostic assessment.** In summary, based on the evidence reviewed thus far, the three major challenges discussed below reveal the reasons for low innovation levels in the region. A first challenge is related to private incentives. Firms in the region have weak incentives to innovate, primarily because sufficient competitive pressure is not there. This would be particularly relevant for larger companies in relatively small markets. In addition, SMEs have little knowledge of the returns associated with innovation activities. For innovative startups, particularly digital ones, there are regulatory frameworks that generate additional costs for their acceleration and growth. There is also limited demand for innovation

from users, including the State, consumers, and regulators.²¹ The second challenge is related to the States in the region underinvesting in government actions. The figures are consistent with the idea that governments underinvest in the public goods needed for innovation and in instruments that leverage private-sector innovation efforts.²² Lastly, the third challenge is related to the weak public institutional framework needed to foster and coordinate STI activities. The evidence presented is consistent with major coordination problems among the different agents involved in the phases of the innovation process, reflecting a weak local institutional framework. That is also true of a poor business climate and weak legal certainty and rule of law, which influence the innovative development of companies.

D. Policy objectives

- 2.27 Based on the three challenges described above, policy objectives need to be established to address them. To that end, a set of policy objectives associated with each of the areas identified is proposed. These objectives are stated in terms of general actions but do not list the specific mechanism or instrument for achieving them. The detailed description of instruments, their design, and their effectiveness in the context of the region are discussed in the following section.
- 2.28 **Lack of private incentives.** The policy objectives in this area involve both established companies and start-ups seeing the potential benefits of stepping up their efforts in STI activities. This might be either by noting that competitive pressure could adversely affect them if they don't provide their users or consumers with solutions that provide greater value or through demand mechanisms—particularly in the public sector—or demonstration effects on the profitability for companies of developing innovations. [Table 1](#) presents a detailed analysis of the policy objectives associated with the lack of private incentives.
- 2.29 **Underinvestment in public actions.** The policy objectives in this second area involve increasing the delivery of relevant inputs for the innovation process and that, owing to appropriability problems, will never be financed by the private sector (public goods). This includes not only generating knowledge, which generally takes place in universities and research centers, but also strengthening the formation of human capital for such activities. It also includes actions promoted by the public sector that seek to incentivize the private sector to invest the financial and intangible resources needed for innovation where without that support they would do so to a lesser extent (information asymmetries and externalities). [Table 2](#) presents six complementary areas of policy objectives associated with underinvestment in public actions.
- 2.30 **Weak public institutional framework.** The low levels of STI in the countries of the region are partly due to the lack of an institutional structure—understood as

²¹ The impact of these incentive-related problems varies not only by type of company (large companies, SMEs, and entrepreneurs) but also by sector. While major strides have been made in opening up the region's economies to international trade, this has not extended to important nontradable and service sectors where deviations from free competition can be significant.

²² Noteworthy among the former are infrastructure (particularly shared infrastructure), financing of foundational knowledge and applied knowledge, advanced human capital, and technical specialists associated with the innovation process. The latter include financial instruments, such as matching grants and R&D subsidies, tax incentives for R&D, support for the adoption and transfer of technology, and early financing of innovative companies through angel, seed, and venture capital.

the set of government agents and their relationships that are directly or indirectly related to support for STI activities—aimed at coordinated, sustained promotion of such activity (Benavente et al., 2019). Beyond the problems noted above, such as underinvestment in public goods, lack of financing, and weak support for resolving market failures in innovation activities, there are known problems like State failures that hinder greater STI work (CNID, 2007, Benavente and Larraín 2016).²³ [Table 3](#) proposes the policy objectives aimed at solving part of these problems.

- 2.31 The next section shows how policy instruments can be used to address these three overarching public policy objectives. While the literature does not have a single conceptual framework for characterizing the different STI support mechanisms, the matrix model developed by the IDB (2014) distinguishes between crosscutting policies (applicable sector-wide) and vertical policies, and between policies that supply public goods and those that change relative prices (e.g. subsidies). These distinctions remain valid, and the three categories internalize the main lesson learned: prepare public policy based on a careful determination of the market failure to be corrected. However, major policy areas that fall outside of this framework must also be incorporated, such as competition and institutional reform of the State. Recently, Edquist (2015) signaled the importance of policies that boost demand for innovation, not just supply, as in previous frameworks. The following section looks at a limited set of public policies with a known design, implementation, and impact.

III. SUPPORT FOR INNOVATION, SCIENCE, AND TECHNOLOGY. INSTRUMENTS, THEIR EFFECTS, AND CHALLENGES

A. Introduction

- 3.1 Based on the three policy challenges discussed in the previous section, the progress in designing policy instruments to support STI, and the IDB Group's own experience with such interventions, a matrix of instruments is proposed that takes into account the previous frameworks and enables us to review the relevance and efficacy of those STI support instruments in the region.²⁴ The grid of instruments presented in [Table 4](#) is divided up according to the three challenges discussed earlier. In addition, the instruments are divided up whether they are supply side or demand side, following recent advances in the literature. Lastly, the instruments have also been classified as public goods, coordination instruments, and tools aimed at resolving both technological and financial information asymmetries. It is worth noting that there are other complementary elements, so the corresponding instruments have a more indirect, albeit important impact on STI activities in the countries, including those related to connectivity and digital transformation.²⁵

²³ In addition to the foregoing, there are also coordination problems in public sector work on these activities. That is to say, knowing there are market failures justifying government action providing some of the inputs companies need to innovate, there is also the problem of coordinating their delivery, since this sometimes does not depend on the institution most directly related to the innovation.

²⁴ How to address these challenges is based on a crosscutting look at instruments ranging from experimentation, direct support to start-ups and established companies, to indirect support through programs executed by the public sector.

²⁵ A detailed analysis of specific policies to support this transformation is available in the IDB Group's 2021 Digital Transformation Action Framework.

B. Instruments for addressing the policy challenges of promoting STI in the region

3.2 The following paragraphs review some of the instruments presented in [Table 4](#), briefly describing their design, main objectives, how they address the policy challenges, and evidence of their success. Since some of these instruments are so new, there may be no evidence on their impact. Others may address more than one policy objective. Likewise, while conceptually these instruments may appear well suited to address the challenges, there is no evidence whatsoever of their implementation, at least in the region. This information is very valuable, as it helps to structure an IDB Group research and knowledge agenda, which is summarized in the final section of this document.

3.3 Private incentives

- a. **Competition policies.** Competition policy seeks to improve the way that markets operate and ensure consumer surplus. To maintain the optimum level of competition in an industry, competition policies penalize anticompetitive behavior. Existing theories suggest that operating in a highly competitive industry can have a positive effect by forcing companies to innovate in order to survive. Stiffer competition can also reduce the payoff for innovation (Romer, 1990; Aghion and Howitt, 1992). The empirical literature finds that competition has a positive linear effect on innovation (Nickell, 1996; Blundell, Griffith, and Van Reenen, 1999). Scherer (1967), in turn, finds a significant inverted U relationship, with heightened competition initially increasing then reducing the rate of innovation—a finding confirmed in Aghion et al. (2005). Several case studies for countries in the region suggest that the impact of competition on innovation differs according to the countries' distance from the global technological frontier (Benavente and Zuñiga, 2021).
- b. **Innovative public procurement.** Historically, governments have applied policies to steer innovation through public procurement from local providers. This system has been used in the U.S. defense industry (creating technologies like the Internet, global positioning systems, and the semiconductor industry). Other iconic examples are using these arrangements to commission products based on new technologies in South Korea, the petroleum supply chain in Brazil, and the security industry in Australia. The public sector may be willing to pay an additional cost to promote certain policy objectives, in this case innovation (McCrudden, 2004; Edler and Georgiou, 2007). For example, Brazil has set a preferential spread of up to 25% for innovative local products, while in South Korea 10% of each public institution's purchases of SME products must be new technology products. Using procurement as an innovation policy tool has been justified to expand the market of certain goods and services, thereby ensuring a sufficient critical mass to promote investment in R&D (Edler, 2010; Cabral et al., 2006). The public sector can also advance standards through procurement by facilitating the dissemination of innovations (OFT, 2004). Innovative public procurement methodologies can also help to overcome systemic failures by allowing for interaction between users and producers, or by signaling unmet needs to the market (Geroski, 1990; Edler

and Georghiou, 2007; Georghiou, 2007).²⁶ Some authors have performed empirical evaluations showing that public procurement of innovation is more effective in generating innovation than R&D subsidies (Rothwell and Zegveld, 1981). There is also literature suggesting that this procurement system can stimulate innovation by expanding the market for new goods and facilitating the adoption of new standards, for example, by incorporating guidelines for products and works with environmental and climate change considerations. What's more, different procedures for public procurement of innovation, by promoting interaction between government buyers and new innovative companies, expand the supplier base, thereby generating greater competition in the bidding process, which should lead to lower prices and better quality (OECD, 2011; OFT, 2014).^{27, 28}

- c. **Demonstrations.** Here, the State supports companies promoting their innovations by showcasing their advantages for potential users. Such programs are aimed at demonstrating the technical and commercial viability of the new technologies and delivering information on the cost of adopting and using new technologies (Fevolden et al., 2017; Clark and Guy, 1998). Demonstration programs have been implemented in a number of developed countries in technological spheres in the agriculture, housing, education, health, transportation, energy, and environment sectors. Harborne and Hendry (2009) evaluate over 200 demonstration projects implemented since 1970 in the European Union, the United States, and Japan, identifying benefits to users of the technologies in the form of lower operating costs associated with the process of learning by using. Palage et al. (2019) investigate the effect of plants used to test new technologies (pilot and demonstration programs) in the biofuel industry. The authors find that the knowledge generated in these demonstrations has had a positive effect on patenting technologies in that industry. Other studies suggesting that such programs are effective in different countries include clean production technologies (Duarte et al., 2005; Sarmiento, 2004) and renewable energy (Baer et al., 1977). Unfortunately, there is no evidence of the impact of such initiatives for countries in the region.
- d. **Connectivity and digital transformation.** As has been evident during the pandemic, deploying digital infrastructure is a prerequisite for closing gaps in access to digital services, enabling the use of technologies by the public sector, and providing for the digital economy and the productive transformation of the private sector. Improving connectivity requires public policies and public-private investment. The region has obsolete regulatory frameworks that do not facilitate the use of technologies in the private sector and public administration. In telecommunications, for example, two out of every three countries have anachronistic laws that do not mention digital elements, broadband or 5G, and

²⁶ There are not many impact evaluations of these arrangements; Uyarra and Flanagan (2009) discuss the difficulties involved in evaluating the impact of such initiatives, particularly when it comes to identifying impacts on public users.

²⁷ Green procurement helps to align public spending with countries' national policies on environmental sustainability and advance fulfillment of international climate change targets and commitments (Delgado et al., 2021).

²⁸ Unfortunately, there is no evidence of the impact of innovative public procurement in the region, since this kind of policy has only recently started to be implemented. Moñuz and Uyarra (2016) provide a breakdown of the design and potential benefits.

only four countries have national connectivity plans (Digital Transformation Action Framework, IDB Group 2021). Digital transformation, in turn, is the use of digital information and technologies to transform activities, processes, competencies, culture, and business models to maximize the opportunities those technologies offer. To promote digital transformation of the private sector and financing for innovative, technology-based business models, the regulatory and policy frameworks required by the generators and adopters of these technologies need to be provided.

3.4 Public actions

- a. **Subsidies for scientific research and research infrastructure.** Funding of science can take the form of individual or collective research projects. The impact of that financing can be measured in terms of the quantity and quality of scientific output. Benavente et al. (2012) present an evaluation of Chile's National Fund for Scientific and Technological Development (FONDECYT) and find a significant positive impact in the quantity but not the quality of research. Chudnovsky et al. (2008) assess the impact of a similar program in Argentina and conclude that the financing (subsidies) the program delivers has a significant positive impact on the performance of academic researchers, particularly younger ones. Moreover, research infrastructures play a key role in enabling and developing research in all scientific fields (OECD, 2020). Research infrastructures make it possible to carry out frontier research, generate knowledge-based development, test prototypes, pilot innovations in real environments, and systematize and analyze information and data, among other things. Examples of research infrastructures include national laboratories of technology services known as "large facilities," astronomical observatories, European Organization for Nuclear Research (CERN) facilities, scientific research ships, and comprehensive information centers. Simmonds et al. (2013) analyze the links between investment in large research infrastructures and innovation outputs. Griniece et al. (2015) study the socioeconomic impact of research infrastructures, in terms of innovation, human resources, and scientific impacts. Lastly, Reid et al. (2018) examine the scope and reliability of different evaluation methods and cite a series of studies applying them.
- b. **Financing of technological institutes.** Public technological institutes aim to promote the development of industries considered to be strategic (defense, agriculture, and health are common examples). The focus on developing smaller companies is also a key part of their mission, as is developing new industries or consolidating others that are in an emerging development phase. Lastly, they are a source of key knowledge for the public sector's own work on regulation for the purposes of environmental protection, infrastructure, and standards-setting. These centers can be evaluated based on the fulfillment of their activities and the results they achieve. Evaluations of this nature include those of four public technological institutions in Chile for the period 2013-2017: the National Standardization Institute, Natural Resources Information Center, Forest Institute, and Fisheries Development Institute (Chile's Production Development Corporation-CORFO, 2017), which found that they had fulfilled their objectives, outputs, and targets.
- c. **Scholarships.** Scholarships are supply-side policy instruments that focus on the generation of new scientific knowledge, both basic and applied, and the

formation of human capital. Most Latin American and Caribbean countries have supply-oriented policies on their agendas today, with this being the crux of science and innovation policy from the 1950s to the mid-1980s (Sagasti, 2011). Scholarship programs cover higher education and postgraduate studies, doctoral and postdoctoral fellowships, and technical training programs, among other things. Traditional scholarship strategies are being complemented by a more deliberate and wider search for talent, and by paying more attention to the development of national programs that will be able to accommodate new Ph.Ds. 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. Still another new set of programs targets the placement of researchers in industry, by subsidizing the hiring by industry of engineers and scientists with advanced degrees, subject to a gradual phasing out of the subsidy until the firms bear the costs of the highly qualified personnel. Gender equality is another relevant component here (Castillo, Grazzi, and Tacsir, 2014), as well as in science, technology, engineering, and math (STEM) scholarships.²⁹ When scientists and engineers have diverse cultures, interests, and origins, together with a gender balance, better scientific and technological results are obtained and those results are maximized (Lane, 1999; NAS, 2006; genTEC, 2011).

- d. **Support for generating standards, accreditations, and certifications.** Standardization is a process that can be imposed by authorities or be voluntary for developing technical specifications. It helps to focus on specific technologies, thereby promoting the development of critical masses in the emerging stages of technologies and markets, which speeds up dissemination of technology attracting fresh investment and developing technologies (Blind et al., 2011). Standards help innovative companies demonstrate to clients that their innovative products have the characteristics they say they have and allow for competition among technologies, which contributes to innovation-driven growth (Swann, 2000). Recent policies have recognized the relevance of standardization, for example Germany's High-Tech Strategy and the European Commission's Lead Market Initiative (Edler et al., 2012), as have research and innovation programs, such as Horizons 2020. Certifications, in turn, are generally voluntary and help dissipate asymmetries of information between those supplying and those demanding knowledge-intensive products and services. They are also useful for producing commodities that have to certify that their production process meets the relevant regulations in different areas such as water and sanitation, or carbon content in power generation sources, to name a few. The Government of South Korea instituted a system for certifying innovative SMEs (Williams and Gurtoo, 2016). This system appears to have been effective in increasing the likelihood that goods and services produced by innovative SMEs are purchased, particularly in high-tech sectors (Edler et al., 2016). No evidence is available on the impact of such policies,

²⁹ According to studies in Uruguay, the probability of being accepted into the country's main research support program is 7.1 percentage points lower for female researchers than for male researchers. Differences in observable characteristics explain only 4.9 percentage points of the gap. In addition, this gap is wider within the higher ranks of scientists, suggesting there is a glass ceiling for female researchers (Bukstein and Gandelman, 2017).

although we do know that meeting standards is one of the main goals of the innovation work of companies in the region (Crespi et al., 2021).³⁰

- e. **Science and technology parks and centers of excellence.** These parks seek to take advantage of geographic proximity, economies of scale and network economies of a set of scientific centers and companies aimed at conducting the different phases of science and technology activities. Squicciarini (2008) compares the patenting activity of Finnish companies inside and outside of science parks from 1970–2002. The results suggest that incubated companies perform better. Ferguson and Olofsson (2004) find that Swedish companies based on new technologies are more likely to survive if they are in a science park compared to a control group. Centers of excellence, in turn, consist of a collaborative network of scientists and institutions that do R&D, including universities. Their goal is to increase the impact of public investment in science and technology by creating critical mass, avoiding fragmentation, and tapping economies of scale. They have a coordination center and tend to be focused on high-potential areas of science and industry (Hellström, 2011; The Innovation Policy Platform, 2013).³¹
- f. **Support for science-technology competitions.** Prizes have been a way of promoting innovation that seeks to engage nontraditional participants with unorthodox approaches to challenges, educate and inspire the public, stimulate incipient technologies, promote the dissemination of technology, address neglected or seemingly unsolvable social problems, and generate “social capital” (Williams, 2012; National Academy of Engineering, 1999). Brunt et al. (2011) perform an econometric analysis of the effect of the Royal Agricultural Society of England’s annual competitions on the production of patents by participants and found that the medals were more important than monetary awards in terms of increasing the number of patents. According to Kay (2011), the Ansari X Prize in the space industry accelerated R&D activity and attracted new innovators. What’s more, the ratio of investments prompted by the prize to the amount of the prize itself was 10 to 1. That author also analyzed the effects of the Northrop Grumman Lunar Lander Challenge, organized by X Prize Foundation in partnership with NASA, and found that the prizes totaling US\$2 million gave rise to US\$20 million in innovative investment.
- g. **R&D subsidies.** While there is extensive literature on the benefits of direct support for R&D activities in developed countries (David et al., 2000; Bloom et al., 2019), evidence for the countries in the region is more limited. Castillo et al. (2019) evaluate the Argentine Technology Fund (FONTAR), which supports companies in innovating, and found a positive effect on jobs, wages, and the probability of exporting. In turn, companies that subsequently hired workers from firms supported by FONTAR significantly improved their performance, which is consistent with the idea of knowledge spillovers associated with labor mobility. In Chile, similar programs, namely the

³⁰ A study in Colombia shows that firms that adopt ISO 9001 standards increase their productivity and wages by 12% and 8%, respectively (Gallego and Gutierrez, 2017).

³¹ As in the previous case, there is no evidence of the parks’ impact; in the case of centers, the Technology Centers supported by CORFO and the National Research and Development Agency (ANID) in Chile are being evaluated.

Technological and Productive Development Fund (FONTEC) (support for intramural R&D) and the Fund to Promote Scientific and Technological Development (FONDEF) (cofinancing for extramural R&D), have similar results. Crespi et al. (2020) evaluate the long-term direct and indirect effects of these programs on the performance of beneficiary companies and also the spillovers on companies not involved. Participation in any of the programs appears to boost the total factor productivity of a company by approximately 4%, however only projects financed by FONDEF appear to generate positive spillovers. Hall and Maffioli (2008) find that FONTEC only impacts export intensity. Alvarez et al. (2012), in contrast, found FONTEC had a positive effect on jobs, wages, and total factor productivity three years after participation. Benavente et al. (2007), looking at a five-year period, find that FONTEC has impacts on sales growth and export intensity but not on labor productivity. Hall and Maffioli (2008) estimate the impact of other programs in Latin American and Caribbean countries, finding that Panama's Fund for Technological and Business Modernization (FOMOTEC) had an impact on sales and productivity and that the program of Brazil's National Fund for Scientific and Technological Development (FNDCT) did not impact the performance of beneficiary firms.

- h. **Financing venture capital and risk capital funds.** Public financing of venture capital funds includes either a government stake in the fund, subsidies or loans to set up the funds, or subsidies to partially finance administration expenses. All of these complement the (majority) private investment in the funds. In the vast majority of cases, these funds have targeted firms' expansion phase, some with pending changes to their technological model, although the majority are looking to scale up their business model. Lerner (1999) presents a list of programs that provide public financing for startups in the United States from 1958-1997. Owen et al. (2019) find that in the United Kingdom government-sponsored venture capitalists (GVCs) have positively impacted sales and jobs in the companies financed. Brander et al. (2010) find that companies that receive financing from both private venture capitalists and GVCs outperform benchmark companies financed exclusively by private venture capitalists, however this difference occurs only when the GVCs make a moderate contribution (a small fraction of the total financing). There is scant evidence on the effect of risk capital funds on leveraging innovation activities, particularly in the region (Benavente et al., 2020). One challenge that these programs need to address in the region is having a gender-based approach, as female entrepreneurs are at a clear disadvantage with respect to men. In Peru, for example, 85% of the entrepreneurs supported by the main government program for innovative entrepreneurship are men (Proinnovate, 2021), while in Uruguay, male entrepreneurship is twice as high as female entrepreneurship (National Research and Innovation Agency (ANII), 2021).
- i. **Technological consortia.** Consortia promote cooperation among companies and between companies and research institutes through formal agreements for developing projects in which the joint R&D investment is aimed at boosting scientific and technological knowledge and applying that knowledge to creating new and improved products and processes (Hagedoorn, 2002; Alvarez et al. 2012). Branstetter and Sakakibara (1998) find that Japanese companies that participate in a consortium increase their R&D spending and boost research productivity, measured as the number of patents received in the United States.

Those authors also find that technological proximity among companies—a measurement of the potential for R&D spillovers—and the emphasis on basic research have a positive effect on the number of patents. Kaiser and Kuhn (2012) perform an impact assessment of consortia in Denmark and find that participating in a consortium has a positive effect on patent applications from years one to three of participation in those projects. This positive impact is also seen in employment but not in the productivity of the firms. The analysis by Dyer et al. (2006) of consortia in the United States concludes that the number of participants and the presence of competitors do not significantly influence companies' performance, as measured by the evaluation of participants and whether or not the company applied for patents as a result of taking part in the consortium. Noteworthy among the factors that improve performance are having effective governance agreements in place within the consortium, frequent communication, and setting ambitious objectives. In the case of developing countries, there is little evidence on the potential effects of consortia (Casalet and Stezano, 2006).

- j. **Sector R&D funds.** These funds (also called Sector Technological Funds and Sector Innovation Funds) are selective policy instruments that aim to build capacity for generating and incorporating technological innovation in sectors considered to be strategic (Crespi and Dutrenit, 2013). These funds, which can also leverage private resources for developing new technologies, are an intervention that recognizes the heterogeneity of the production system and the specificity with which knowledge is incorporated in each sector. The region has examples of sector funds in energy, agroindustry, health, water and sanitation, port development, biotechnology, nanotechnology, the aeronautical industry, and information and communications technology. In some cases they are financed with levies on specific sectors, including development of natural resources, such as in Chile (Innovation Fund for Regional Competitiveness) and some sector funds in Brazil. The National Research and Innovation Agency (ANII) (2015) presents an assessment of the impact in Uruguay of the Innovagro Sector Fund (FSA) and the Energy Sector Fund (FSE). In terms of academic output, the main results translate into publications in scientific journals and some technical products, particularly in the case of the FSE. Human resources training was noteworthy in the FSA, with an average of nearly one researcher trained in the context of participation in research projects. Kannebley et al. (2013) assess the impact of Sector Funds in Brazil on the scientific productivity of the academic researchers benefiting from those programs in the period 2000-2008. The evidence obtained shows a positive impact on the researchers in the sample.
- k. **Tax credit for R&D.** Tax credits for R&D spending reduce the tax burden of companies that make such expenditures. That is to say, they lower the “price” firms pay for conducting R&D. In that regard, they are an indirect tax incentive (there is forgone tax revenue associated with lower tax receipts). Evidence has been compiled primarily for developed countries, based on quasiexperimental methods, which suggest that tax credits are generally effective in boosting private R&D, with price elasticity of around minus one (Hall and Van Reenen, 2000). More recent evidence for the United States, France, and the United Kingdom confirm these findings (Chang, 2018; Mulkay and Mairesse, 2012; Dechezlepretre et al., 2016; Guceri and Liu, 2019). In addition, Hall (1993) and

Mulkay and Mairesse (2012) have found evidence suggesting that the increased R&D spending is roughly equal to or even greater than the forgone tax revenue associated with providing the tax credits. In Chile, in 2017 the Ministry of Economy published an impact study of the R&D Law, which found that it would have impacts on leveraging private resources of nearly 6% for each 1% in additional tax incentive (Minecon/Intelis, 2017). An evaluation of these incentives in Argentina found that the elasticity between the cost of capital net of tax and investment in R&D and innovation was similar to that of OECD countries (Crespi et al., 2016).

- l. Loans for adoption.** Soft loans are a direct instrument used to support financing of innovation projects.³² In the area of innovation policy, the loans are generally issued at below-market rates by intermediary financial institutions that administer government funds or funds from development banks. There are different types of innovation loans. The most common are unconditional loans, which need to be paid back regardless of the outcome of the innovation. In general, the evidence supports these interventions having a positive impact on R&D intensity (R&D/sales). This includes the lending program of Brazil's development bank (BNDES) (Machado, Martini, and Gama, 2017) and the soft lending program at Spain's Center for the Development of Industrial Technology (CDTI) (Huergo and Moreno, 2014), who also find that the positive effect of loans on R&D intensity is greater than that of subsidy arrangements; the French program ANVAR (Warta and Rammer, 2002) and the program at Turkey's Technological Development Foundation (TTGV) (Özçelik and Taymaz, 2008). Lastly, IDB-OVE (2017) find that the BNDES program in Brazil has positively impacted labor productivity, and Huergo and Moreno (2014) show that Spain's CDTI increases product innovations and patent applications.
- m. Guarantees for technological adoption.** These programs are aimed at covering part of the risk associated with potential losses borrowers experience when companies are delinquent on their loans (Beck, Klapper, and Mendoza 2008). Thus guarantee arrangements seek to encourage banks to issue loans they might not otherwise grant and to thus support innovation projects that otherwise would not be carried out or would be conducted on a smaller scale. Among the most popular guarantee programs are those promoted by the Korean Technology Finance Corporation (KOTEC) and Spain's CDTI. For the former program, Heshmati (2013) shows a positive effect on the growth of sales and productivity for participating companies, particularly for the youngest and most technologically advanced participants. For the CDTI program, Huergo et al. (2013) find that the likelihood that participants invest in R&D was 25% higher than in companies that did not participate. The effect was even stronger for SMEs.
- n. Extension programs.** Extension programs promote disseminating available technological knowledge, adapting it to the reality of the companies, and making available to them methodologies that facilitate the adoption, adaptation, and use of developed technologies outside the companies being supported. Castillo et al. (2016) find that the Competitiveness and Access to

³² It should be noted that this type of mechanism is not exclusive of implementation of public policy but rather seeks complementarities with private efforts and resources and can be structured directly through private parties. One example of this is the Clean Technology Fund implemented in Chile.

Credit Program for SMEs (PACC) in Argentina has a significant positive impact on jobs, exports, survival rates and productivity and that most of the program's additionality was achieved during the initial technical assistance provided; they therefore recommend targeting government efforts on registering new companies. Castillo et al. (2014) evaluate the PRE program in Argentina and find significant effects on jobs and real wages. Lipscom et al. (2017) show that the Manufacturing Extension Partnership in the United States leads to increased labor productivity. Maffioli et al. (2013) show that the Farm Modernization and Development Program (PREDEG) in Uruguay has a significant impact on planting density while López and Maffioli (2008) find that the Livestock Pilot Project in Uruguay had a significant impact on the adoption of management practices.

- o. **Open innovation.** Open innovation programs build in the fact that, due to accelerated technological change and increased complexity, the corporate innovation model has been evolving toward working in a network with different actors in the ecosystem (Chesbrough, 2003). These arrangements are based on having a large corporation challenge the ecosystem with its production problems, thereby generating a process of collaborative innovation between the firm and actors in the ecosystem. These types of programs aim to address shortcomings that prevent greater collaboration, notably information asymmetries, misaligned incentives, and weak capabilities in supply of and demand for knowledge. Despite the growing popularity of open innovation models, there is limited evidence of their impacts. Exceptions are Rauter et al. (2018) and Lu and Chesbrough (2020), who found that open innovation practices have positive impacts on companies' performance. While such programs are just beginning to emerge in the region, they are especially important for incentivizing synergies between the IDB, IDB Invest, and IDB Lab.

3.5 Institutional framework

- a. **Innovation climate.** This is also called the innovation ecosystem or, in the broader sense, the business climate and refers to the conditions in the environment that favor innovative performance by companies. A stable business climate has proven essential for companies to commit to the challenge of innovation, i.e. for them to work in a substantially different and more productive way thanks to innovation and technology. This is particularly true in the digital economy. Indeed digital ventures are directly behind the emergence of entirely new business models based on exchanges, business linkages, disintermediation, and open innovation. All of this highlights the renewed relevance of the innovation and business climate (IDB, 2010). Some authors suggest that improving the business climate through dialogue between the public and private sectors, reducing regulatory costs, transparency and competition, technological development and innovation, value chains and clusters, export promotion and access to finance could help companies, particularly those lagging far behind in terms of productivity (Acs, Stenholm, and Wuebker, 2010; Hallward-Driemeier and Pritchett, 2011).
- b. **Promotion of intellectual property.** One of the most relevant institutions for promoting innovation is the protection of intellectual property (Shapiro, 2002). Unlike support through subsidies, which compensates the innovator ex ante,

intellectual property rights compensate the innovator ex post. And for this to happen, a set of regulations and monitoring mechanisms needs to be in place to protect the rights of the invention's developer. Active promotion of intellectual property should consider that temporary monopolies are formed, which could adversely affect the new knowledge spreading at a healthy pace in the economy. Therefore, there is a balance between enforcement of intellectual property and the timeframes in which it can then be disseminated, so a strong institutional structure needs to ensure the proper balance is struck. Boldrin and Levine (2009) find a positive relationship between protecting intellectual property rights and innovation, however the evidence is more sound for developed countries than for developing ones. These authors cite findings from 23 empirical evaluations on the relationship between protecting intellectual property and innovation, all written between 1979 and 2002 with data from developed countries. The majority find little to no evidence that strengthening patent regimes (one specific form of protection that is also the most common) increases innovation. In turn, Kim et al. (2012), based on a panel of 70 countries for the period 1975-2000, conclude that patentable innovations contribute to economic growth in developed countries but not in developing ones. In developing economies, they find that utility models favor innovation and growth more when they are associated with smaller incremental inventions. In other words, sector specificity and the distance from the technological frontier are key elements that must be taken into account when designing an appropriate intellectual property protection regime.

- c. **Strengthening the public institutional framework.** The majority of actions suggested in this section require active involvement of the public sector. And for this, the State must have the capabilities, infrastructure, and knowledge to do that work efficiently and effectively. It is to that end that countless actions have been taken to strengthen those capabilities. Both in the developed world (Paic and Viros, 2019) and in some countries in the region (CNID, 2007), measures are being put forward for strengthening the institutional structure while aiming to avoid the failures of the State discussed above. Nevertheless, to date there is no evidence on their impact, with the few exceptions cited by Lane (2019) for South Korea.

IV. LESSONS FROM IDB GROUP EXPERIENCE IN THE SECTOR

- 4.1 The Knowledge and Learning Division (KIC/KLD), in coordination with IDB Invest and IDB Lab, supported the Competitiveness, Technology and Innovation Division (IFD/CTI) in analyzing a sample of 22 sovereign-guaranteed operations,³³ 12 technical cooperation operations,³⁴ 3 IDB Lab operations,³⁵ and 5 IDB Invest

³³ The operations examined can be divided into three groups. The first encompasses projects in an advanced stage of execution (DR-L1068, AR-L1156, AR-L1181, AR-L1310, BR-L1490, CH-L1148, PR-L1086, UR-L1142, and JA-L1085). A second group includes projects closed since 2017 (BR-L1020, GU0163, DR-L1121, CH-L1134, PE-L1244, PN-L1149, BH-L1050, PE-L1068, AR-L1141, and UR-L1071). A third is comprised of projects that were canceled or on alert status (GY-L1059, PR-L1070, and CH-L1105).

³⁴ The technical cooperation operations approved after 2021 are: CH-T1214, RG-T3232, RG-T3342, BH-T1062, PE-T1399, RG-T3338, RG-T3330, RG-T3252, RG-T3000, PN-T1160, RG-T2915, and RG-T2957.

³⁵ AR-Q0017, UR-T1150, and UR-T1198.

operations.³⁶ This analysis was based on a review of documentation related to the selected projects³⁷ and on interviews with the Project Team Leaders. The lessons learned complement those identified in the previous SFD, the recommendations in which remain valid. The health crisis has shaped the STI development agenda, which has required that this chapter focus on specific interventions for the current challenges.

- 4.2 The lessons have been organized under the three challenges that are at the heart of this document—interventions to strengthen private incentives, interventions to address public underinvestment and address market failures, and interventions aimed at strengthening the institutional framework. Below is a series of strategic and operational lessons aimed at improving the IDB Group's work to support this type of activity.

A. Technical lessons

1. Lessons from interventions to strengthen private incentives

- 4.3 The Bank's work on **interventions aimed at closing gaps in strategic sectors highlights the advisability of focusing** not only on relatively higher impact crosscutting **reforms** but also on reforms that are key for **strategic sectors, aligning public policy priorities with citizens' needs with a view to mitigating the risk of "cuts" in adverse macroeconomic contexts**.³⁸ The identification of these areas of growth should be based on the comparative advantages of each country, considering (i) their export potential; (ii) their impact on the development of other sectors; and (iii) their potential to improve the territorial balance. The experience in Argentina, Chile, and Brazil³⁹ highlights that it is key to prioritize reforms that are part of the countries' competitiveness programs and/or road maps, to ensure interventions are effective and relevant. Specifically, active monitoring mechanisms were implemented in Chile for each project financed, which made it possible to be selective in allocating resources. Lastly, it should be noted how important it is for the institutions that support innovation to meet the needs of society, which requires communicating the benefits of the innovations being promoted. This outreach work makes it possible to mitigate the risk of cuts in the countries' allocations in times of crisis.

2. Lessons from interventions to address underinvestment in public actions

- 4.4 **Policies that improve the supply of advanced human capital in science and technology**, through aid for professionals and the promotion of human resources training in international centers, **have benefited from the Bank's participation, which has leveraged and complemented the resources available for scholarships in numerous projects**. The experience in this type of intervention underscores the importance of: (i) promoting the contribution of third parties, including the business sector, not only for financing scholarships but also for better

³⁶ This analysis was based on a document review and interviews with Project Team Leaders for the following IDB Invest projects: PTI Bolivia (12523-01), Internet para todos (12361-01), Cargo X (13095-01), Mercado Crédito (12313-01), and SVB (12494-01).

³⁷ This exercise was carried out through a review of project completion reports, project monitoring reports, loan proposals, technical notes, impact evaluations, and other relevant documents.

³⁸ PE-L1244, AR-L1181, PN-L1149, and BR-L1490.

³⁹ AR-L1181, CH-L1134, and BR-L1490, respectively.

- promoting increased ownership of the programs, facilitating job placement for scholarship recipients; (ii) establishing agreements with agencies specializing in scholarship management; (iii) designing selection mechanisms that take into account the country's political economy, for example, with more automated procedures in more embryonic systems; and (iv) having a job placement strategy for scholarship recipients through agreements with companies and institutions in priority sectors. Experience in Argentina and Uruguay⁴⁰ indicated that, through scholarships, in addition to promoting the acquisition of specific skills among professionals and technical specialists, there are benefits associated with the international exposure they will gain, which will help them join global professional cooperation networks.⁴¹
- 4.5 **Operational experience also demonstrates the relevance of scholarship programs being accompanied by regular evaluations.** It is recommended that the capacity of executing agencies be strengthened in order to properly monitor beneficiaries. Specifically, one of the main conclusions drawn from Argentina's BEC.AR scholarship program was the need to (i) identify the best timing for performing the evaluations and identifying the impacts of the scholarships; and (ii) dig deeper into how best to capture the systemic contributions of the different profiles in their work environments.⁴²
- 4.6 **The COVID-19 crisis has demonstrated the urgent need to promote human capital and digital skills in the region.** In this context, and for the purposes of improving the adoption and integration of advanced technologies in companies and institutions, the IDB Group has played an essential role. **Bootcamps are a successful model for providing the labor force with digital skills and responding to the shortage of digital talent in the region.** The experience of the IDB Group, and IDB Lab in particular, in holding bootcamps in Costa Rica, Uruguay, Ecuador, and Peru highlights how essential it is for policymakers to understand the local context, to make any necessary adaptations to bootcamp programs, for the public sector side to perform sound analysis of the shortage of advanced digital training in the economy, and for there to be in-depth knowledge of the technological pathways in specific industries, so as to select the best policy tools. Other lessons learned from operational experience are: (i) determine the main obstacles students face to better absorb the training model (i.e.: deliver financial aid, provide laptops, scholarships for underrepresented groups); (ii) include the development of interpersonal skills; (iii) coordinate learning mechanisms that ensure private sector leadership; and (iv) make international tendering be for the entire package of services, not just for computing services.⁴³
- 4.7 **The IDB Group has financed operations aimed at promoting digital transformation** through a combination of delivering information on the benefits of digitalization, nonreimbursable technical assistance mechanisms, in the form of vouchers, matching grants and loans, private sector financing, and through **policy reforms focused on public procurement.** Some governments have stepped up

⁴⁰ AR-L1156 and UR-L1142, respectively.

⁴¹ PR-L1086, AR-L1156, and UR-L1142.

⁴² AR-L1156 and UR-L1142. The BEC.AR program used linkage and dissemination tools, including a virtual platform (<http://bec.ar>) to track beneficiaries during and after they have completed their scholarships.

⁴³ Talent disruption. The advent of programming bootcamp and the future of digital skills, business digital transformation. How to level the playing field. RG-T3683. RG-T3232.

the development of new digital solutions through public procurement for innovation. Specifically, the experience in Peru,⁴⁴ which launched a social innovation challenge (I+D+i Bio and Perú Resiliente), faced certain challenges showing the importance of: (i) adjusting the public procurement framework for stepping up the procurement of innovative solutions, and (ii) building the capacity of companies and institutions to effectively use innovative public procurement (e.g., with supplier development platforms, technological extension, and certification).

- 4.8 The Bank has also supported mobilization of digital adoption through public procurement reform, for example, by requiring use of the Building Information Modeling (BIM) methodology in public works construction projects, which requires developing common international standards that facilitate collaboration with different suppliers and information management, which needs to have data interoperability at the project level.⁴⁵ **The development of common international standards promotes technological adoption in a context of reliability for all stakeholders.**

3. Lessons from interventions focused on addressing market failures in innovation

- 4.9 The Bank's work finds that **companies that access technical support instruments have levels of investment in innovation activities that grow over time, but a combination of actions is needed to address innovation gaps.** These instruments have boosted the capacity, innovation processes, and technological modernization of companies. In some cases, the Bank has supported companies in preparing projects and familiarizing them with technological advances, in order to develop basic skills. In others, the combination of loans and nonreimbursable financing has promoted the sustainability and creation of a better system of incentives, providing reimbursable instruments in the areas of business modernization with fewer externalities and reserving nonreimbursable financing for projects with a demonstration effect. Nevertheless, the sector's experience indicates that challenges remain for reaching companies with the potential to innovate, which must be approached through a combination of communication, training, and greater diversity in available financing instruments.⁴⁶
- 4.10 **Comprehensive digital support systems for companies enable beneficiaries to move between programs and use support mechanisms based on the needs of the moment.** Comprehensive policies to support digital transformation require taking an approach that makes it possible to act simultaneously on the different levels of digital capacity and company needs, as well as in each stage of the technological innovation chain, considering both financial and technical aspects. It is key that program design be tailored to the specific characteristics of each ecosystem, combining the various support instruments as is most appropriate.

⁴⁴ PE-L1068.

⁴⁵ For example, in Chile's BIM Plan. Business digital transformation. How to level the playing field. RG-T3252, PE-L1068. <https://blogs.iadb.org/innovacion/es/la-orden-de-compra-que-puede-cambiar-la-vida-de-una-startup/>.

⁴⁶ AR-X1015, PE-L1068, and AR-L1141.

- 4.11 **Operational experience shows that as innovation systems mature support to companies needs to be supplemented with systemic interventions**, to both strengthen the supply and to coordinate the actors. A sound ecosystem is needed to promote innovation and entrepreneurship in the private sector—which in turn requires elements to be in place such as a regulatory framework, the capacity of intermediary institutions to provide support tailored to entrepreneurs in each stage, skilled human capital and venture capital, among other things—together with an enabling environment in which they can grow. In that vein, the intervention of both the public sector and the private sector is essential, given their capacity to bring together the main stakeholders in the early stages of building the system. The IDB Group's experience promoting open innovation in Brazil and other countries in the region is of great interest, particularly IDB Lab's work aimed at facilitating development of the ecosystems through knowledge and complementary investments. In general, the lessons learned show that dynamic entrepreneurs need not only the financial framework but also complementary public inputs like training, incubators, accelerators, a functioning framework for protecting property rights, and technological resources. In Peru, for example, the StartUp Perú initiative not only promoted innovative entrepreneurs but also incubators, accelerators, local and international investors, universities and large companies that tapped the business opportunities stemming from the projects identified in the program.⁴⁷
- 4.12 **Innovation and entrepreneurship promotion programs** underscore **several key lessons**, including: (i) their integrated nature, acting simultaneously on each stage of the entrepreneurial process, considering both financial factors and support services; (ii) taking advantage of existing capacity to support entrepreneurship by strengthening areas that have weaknesses as the system matures; (iii) private sector involvement, through angel investors, investment funds and incubators, in all support bodies, to correct financing and equity holding gaps; (iv) the importance of having thorough selection mechanisms and comprehensive due diligence and monitoring processes; (v) the need to understand innovation as a crosscutting issue that also requires the relevant human capital formation, sound public management, sustainable infrastructure, and digitalization, among other things, so STI can develop and flourish; and (vi) the need to maintain a gender approach in interventions to promote balanced access to the instruments.⁴⁸

⁴⁷ JA-L1085, PE-L1068, and PE-L1162.

⁴⁸ UR-L1142 and JA-L1085.

- 4.13 **Operational experience indicates that it is important for the mechanisms for selecting innovative, dynamic ventures to be based on objective indicators of the ventures' success.**⁴⁹ A recent Bank study (Goñi, 2020) underscored the relevance of supporting ventures with better human teams and feasible innovations, as they have the most potential to yield benefits for the entire economy. StartUp Perú demonstrated that selection mechanisms based on soft skills did not lead to selecting the right candidate, so the selection process was adjusted to add observable factors of success, such as entrepreneurial experience and the positioning of the venture. Another recommendation is to include tools in the design phase that help correct potential biases among judges, such as setting up a selection panel with three judges on a revolving basis. Lessons learned from Peru's experience have informed the design of other programs in the region, including in Jamaica.

4. Lessons from programs aimed at strengthening the institutional and regulatory framework

- 4.14 The Bank plays a **catalytic role** in reform operations to improve the business climate, specifically in **implementing** novel reforms in strategic areas, such as funds for financing technology transitions. Chile⁵⁰ demonstrated that properly structured and run Strategic Investment Funds can be effective vehicles for leveraging private investment for financing strategic investments, thereby multiplying the capital's capacity to have an impact. Specifically, Bank support through Strategic Investment Funds made it possible to structure financing for challenging projects over the long term. That experience and other interventions focused on regulatory reforms, such as in Peru, the Dominican Republic, and Chile,⁵¹ show the importance of institutional reforms being accompanied by technical cooperation operations for strengthening an executing agency's in-house capacity, while providing technical support to strengthen the management of monitoring and evaluation. Linking the outputs of technical cooperation operations with the conditions for policy-based loans, and the use of loans based on results in interventions aimed at building a new institutional framework have been identified as good practices.⁵²
- 4.15 **The situation caused by COVID-19 has forced many agencies that support business innovation** to adapt how they work to make their management more agile. Both in Latin America and in Europe, the pandemic has accelerated digitalization of the operations of many innovation agencies. However, the management capacity of programs and instruments still needs to be improved to finance innovation activities, developing high-quality, transparent decision-making processes. In addition, monitoring and evaluation tools should be strengthened to oversee the continuity of the work financed. It is recommended that nonreimbursable instruments be used to support the countries in strengthening operational issues and/or building dialogue, especially in countries with weak institutional structures.

⁴⁹ PE-L1068, PE-L1162, JA-L1085, What Works.

⁵⁰ CH-L1134.

⁵¹ PE-L1244, DR-L1121 and CH-L1148, respectively.

⁵² BH-L1050, PE-L1244, DR-L1121, CH-L1148, and AR-L1310.

- 4.16 **Strengthening the gender perspective in designing competitiveness, technology and innovation policies requires a coordinated effort with actors in the ecosystem, both nationally and internationally, through partnerships and the increased dialogue** being promoted through platforms like Gender Summit.⁵³ In recent years, the Bank has promoted the explicit incorporation of gender issues in several of its operations through the promotion of women's participation in research projects, gender affirmative action in scholarship programs, special research competitions on gender issues, etc.⁵⁴ Intense work has also been done on estimating the economic cost of women's exclusion in certain STI activities and producing indicators for detailed analysis of the gender gap.⁵⁵ Knowledge generation work should be complemented with activities aimed at fostering dialogue with key actors that influence public policies. It should be noted that, while there is plenty of room for improvement for building technical capacities in this area, such efforts should be complemented by actions aimed at partnering with key actors in the ecosystem in new areas that make it possible to inform policymakers and influence the design of public policy.⁵⁶

B. Strategic and operational lessons

- 4.17 One of the main lessons learned in recent years is the fundamental complementarity between the development of knowledge within the IDB Group on STI activities and how this knowledge has materialized in the design of operational instruments. Moreover, the cumulative knowledge has been fueled by scientific advances on these activities—where the IDB Group has had major involvement—but is also based on experience on the ground, which helps in reassessing existing instruments and suggesting new ones. This is reflected in the abundant literature cited at the end of this document and in the following paragraphs of this section, which illustrate this virtuous cycle of knowledge-operations-knowledge.
- 4.18 **The effects of the COVID-19 pandemic have yielded a number of lessons that need to be addressed through a structured response based on science, technology, and innovation, for a faster exit from the crisis and to promote a swift economic recovery.** The first recommendation is to support companies with liquid contributions through emergency interventions, accompanied by programs to cohesively support innovation and dynamic entrepreneurship. Peru's experience highlights the importance of deploying instruments that incentivize the digital transformation of companies in response to the pandemic's impact. Second, it is key for the countries to have local capacities to coordinate a response tailored to the context of the region and that is effective in response to future systemic shocks. In this vein, the Bank has been supporting the strengthening of infrastructure, laboratories, and human capital in several countries, for example in Argentina (AR-L1310), Paraguay (PR-L1086), and others. Third, experience has shown that countries with more robust institutional capacities and more solid innovation ecosystems have had a more efficient response to the crisis, which highlights the importance of: (i) supporting capacity-building in the countries; and (ii) promoting regional collaboration through cross-learning among the region's

⁵³ See: <https://gender-summit.com/>.

⁵⁴ CH-L1148, AR-L1310, and CH-T1256, respectively.

⁵⁵ See a summary of these results in Grazzi et al. (2019).

⁵⁶ A notable example was the recent launch of Chile's National Policy on Gender Equality in Science, Technology, Knowledge, and Innovation (<https://www.minciencia.gob.cl/genero/>).

countries. Lastly, the window of opportunity provided by the COVID-19 health crisis to promote the digital transformation agenda and new businesses (paragraph 4.15) should be noted, as it requires redefining priorities in response to pending challenges.⁵⁷

- 4.19 **The Bank is a strategic partner for countries by providing technical advisory support that aligns innovation policy with the challenges faced by the countries in priority areas** (such as environmental challenges, digital transformation, health, and the circular economy). **Through knowledge networks, strategic partnerships with global benchmarks in innovation,⁵⁸ and its work as a trust broker between public and private actors, the Bank has provided uninterrupted support to the region's countries in: (i) creating or strengthening innovation agencies; (ii) enhancing the capacities of companies and research centers; and (iii) designing instruments to promote innovation.** The Bank continues to provide financial support to countries for the formulation of policy reforms or operations to promote innovation in priority areas on the countries' roadmaps, and also provide technical advisory support by generating new knowledge on strategic issues, as in the case of promoting the orange economy in Panama, Peru, Chile,⁵⁹ and many others. It has also been a trust broker between the public and private sectors and civil society, such as in Chile where the Bank led a dialogue that culminated in the design of the Ministry of Science, Technology, Knowledge, and Innovation.⁶⁰ Likewise, the Bank has provided a venue for the exchange and dissemination of high-level technical knowledge for sector researchers and policy-makers. Another knowledge network supported by the Bank is the Latin American Network of Innovation Agencies (ReLAI), where participants share experiences and coordinate to overcome common challenges.⁶¹ Another example of the services the IDB Group provides is LACChain, a public-private consortium of actors for the ethical use of blockchain-based tools. The standards developed by this initiative have been recognized globally (by ITU) and have a wide reach in the region's countries. Lastly, it should be noted that the Bank has also supported actions with a demonstration effect. For example, it has financed bootcamp operations to help increase the number of programmers in the ecosystem with encouraging results, which has enabled public policy-makers to incorporate this training modality as a valid intervention option.
- 4.20 **Science and technology projects have used the various available financial instruments in a cohesive manner.** The existence of technical cooperation funds to support STI operations has been key. In Paraguay,⁶² technical cooperation was crucial for building executing agencies' capacity to lead and continue reform processes. In Chile,⁶³ support was provided for establishing productivity and competitiveness policy measures and for designing and implementing monitoring

⁵⁷ Responding to COVID-19 with Science, Innovation, and Productive Development (IDB, 2020), AR-L1310, PR-L1086, and PE-L1068, respectively.

⁵⁸ These include Google, Microsoft, and institutions like the MIT Media Lab and the World Economic Forum's Centre for the Fourth Industrial Revolution, and these relationships are coordinated by the Office of Outreach and Partnerships (ORP).

⁵⁹ PN-L1149, PE-L1068, and CH-L1148, respectively.

⁶⁰ CH-L1148.

⁶¹ PN-L1149, PE-L1068, CH-L1148, ReLAI, PE-L1244, and CH-L1134.

⁶² PR-L1086.

⁶³ CH-L1148.

and evaluation systems.⁶⁴ The use of these instruments is recommended for the design and implementation of public policy demonstration pilots, leveraging their flexibility. At the same time, the use of the conditional credit line for investment projects (CCLIP) in Argentina and Uruguay allowed for an extended learning and funding period, so this modality should be considered in countries with innovation agencies that have management capacity.

- 4.21 **The IDB Group has sought to provide a coordinated, expandable, and comprehensive financial solution to the innovation ecosystem, through fluid interplay among the IDB Group's different windows.** On one hand, IDB Invest has addressed the funding needs to promote the growth of science and technology companies (as well as others) in the region, by using the right financial products for the client's needs, and through novel financial instruments such as debt funds for startups (SVB Regional) and special purpose vehicles (PTI). Equity contributions have become an appropriate product for the expansion of competitive digital platforms. IDB Invest has also supported enhanced connectivity and increased efficiency in the telecommunications sector through the promotion of shared digital infrastructure models by means of special purpose vehicles (PTI). At the same time, IDB Lab, as the IDB Group's innovation laboratory, through support in the form of seed capital and technical support for testing business models, has scaled up a number of innovative initiatives through venture capital funds in close collaboration with other areas of the Bank. Examples include the case of CITES, where it supported the acceleration of disruptive technology-based startups to address social and/or environmental problems, and the technical cooperation provided by IDB Lab in Uruguay's National Research and Innovation Agency (ANII) to strengthen innovation in the creative and logistics sectors.⁶⁵
- 4.22 **The IDB Invest investments maximize their impact by selecting an accredited partner who is a cutting-edge leader in the sector.** For example, in the case of digital innovation operations with infrastructure-sharing models, having a partner with knowledge of the country, a broad network of local contacts, and a solid track record in the sector is key to ensuring a high impact and the sustainability of the operation.⁶⁶
- 4.23 **Digital platforms focused on vulnerable populations need policies that ensure positive social and environmental benefits are attained.** The involvement of IDB Invest Advisory Services has been key in adopting standards guaranteeing good corporate governance, as well as developing social and environmental management systems that identify, evaluate, and manage environmental, social, health, and occupational safety risks, and prepare studies to measure gender diversity, so as to increase promotion of diversity. Advisory Services add value in digital platform transactions by developing corporate governance that includes policies on information disclosure to shareholders and related parties.⁶⁷ Blended finance interventions are effective in innovative businesses, such as digital platforms, where the predictability of revenue and system optimization are key. Likewise, promoting ethical standards on the use of

⁶⁴ BH-L1050, CH-L1148, DR-L1121, PE-L1244, and PR-L1086.

⁶⁵ PTI, SVB, UR-T1150, UR-T1198, and AR-Q0017.

⁶⁶ PTI, Mercado Crédito

⁶⁷ Good practice taken from CargoX, as well as the experience of Cabify, Uber, and others.

artificial intelligence (AI) tools through the fAIr LAC initiative is another example of the joint work of the IDB Group.

- 4.24 **Coordinated work between the IDB, IDB Lab, and IDB Invest enables them to offer a range of products and services tailored to the needs of their clients, supporting innovative startups in their various stages.** The lessons learned described in previous paragraphs identify various synergies between the three entities within the IDB Group. While not strictly linear, these help to underscore IDB Lab's importance as a provider of technical assistance services for testing policy interventions in controlled contexts. These interventions can then be scaled up, after the corresponding evaluation, through the IDB's public financing programs. Later, companies and startups with technically- and commercially-proven innovative prototypes can receive early-stage financing, either directly from IDB Lab or through some of the regional venture capital funds that it finances. Lastly, companies that need subsequent rounds of investment, as well as scaling up of their operations internationally, can receive financing from operations funded by IDB Invest. Coordinated action and synergy among the different entities within the IDB Group helps reduce risk and maximize the benefits of innovation in the region.
- 4.25 Interventions in innovation, science, and technology demonstrate that in most countries in the region, innovation and entrepreneurship agencies operate in institutional frameworks where there are agencies working in complementary areas (such as furthering investments and exports, and business development). **Experience shows that it is key to have institutional arrangements among the different government entities to achieve synergies aimed at promoting innovation, in order to obtain better results.** Along those lines, Guatemala's experience⁶⁸ highlighted the importance of not overestimating in the design phase the **public-private** coordination capacity needed for executing projects.
- 4.26 Regarding **public-private coordination**, the Bank's work in Brazil, Paraguay, Panama,⁶⁹ among others, **underscores the importance of having mechanisms or bodies that strengthen ties to the private sector, to harmonize public and private strategies and outlooks, with a view to ensuring ownership, targeting, and prioritization.** In Brazil, different awareness-raising meetings were organized with companies in local industry clusters, to overcome the risk of private sector mistrust and promote program governability. In Paraguay, the establishment of a mixed governance committee with the private sector, academia, civil society, and government, made it possible to have a space for dialogue on key questions for the scholarship program and proved to be very useful and relevant, both for decision-making and for program ownership by each actor in the system. In that vein, Chile's experience highlights that interventions focused on strategic sectors benefit from being designed in environments with multi-actor governance.⁷⁰
- 4.27 Experience in Colombia, Chile, and Argentina stresses **the importance of policies having a clear coordinated effort throughout the country**, to improve the territorial balance in terms of innovation. For this, fostering interaction with

⁶⁸ GU0163.

⁶⁹ See <https://cl.socialab.com/challenges/unrespiroparachile>.

⁷⁰ PR-L1086, AR-L1156, CH-L1134, BH-L1050, GU0163, and BR-L1020.

regional governments, cities, and other subnational actors is recommended while they build innovation capacity and innovative entrepreneurial capacity in the country's regions.

- 4.28 **Sector reforms require the commitment of senior authorities and high-level leadership** to achieve satisfactory results in strengthening and/or creating institutions. In Chile and Argentina, high-level political backing was essential for aligning the efforts of all involved and thus carrying out the program's agenda.

V. LINES OF ACTION

- 5.1 This sector framework document proposes that IDB Group work on innovation, science, and technology should help close productivity gaps and address challenges stemming from Vision 2025 in the countries of Latin America and the Caribbean. Based on the diagnostic assessment in Section II, the literature review in Section III, and the lessons learned documented in Section IV, five lines of action are proposed, as a reference for the IDB Group's work that will then have to be contextualized and timed based on the situation in each country.
- 5.2 Because of the considerable heterogeneity in the development of national innovation systems and in the economic structure of borrowing countries, strategies for designing and executing operations must be formulated on a case-by-case basis. In each case, the decisions taken in this regard will be guided by three main criteria: (i) the pre-existing institutional capacity for implementing particular programs or reforms; (ii) the distance between the main economic sectors affected by the operation and the technological frontier, and its potential as a basis for economic diversification;⁷¹ and (iii) the degree of development of the available knowledge infrastructure (local availability of inputs for innovation). Likewise, the lines of action proposed below are incumbent on the IDB Group as a whole, which will seek synergies among its different windows.

A. Line of action 1: Operating principles

- 5.3 To the extent possible, IDB Group operational and knowledge work in the STI sector will be guided by the following general principles:
- a. Building institutional capacity in national innovation systems, following the internationally sanctioned good practices in the field, remains a major area of focus in the design of all IDB Group operations.
 - b. Activities, programs, and policy instruments supported in the context of IDB Group operations tend to respond to a clearly identified market failure or static or dynamic coordination failure.
 - c. In line with common practice in risk evaluation processes, stakeholders' capture risk and the risk of dynamic inconsistency in execution are minimized and mitigated in the design and implementation of Bank interventions.
 - d. Given the heterogeneity of baselines in material, intellectual, and institutional resources across economies in Latin America and the Caribbean, the IDB Group will strive to tailor its lending, advisory services, and technical assistance programs in the sector to the specific needs of each country at any

⁷¹ See Development in the Americas (IDB, 2014) for guidelines regarding how to operationally assess this criterion.

given time. This will be done bearing in mind crosscutting issues of interest to the entire IDB Group, such as inclusion, climate change mitigation and adaptation, and digitalization of the economy.

- e. As indicated in the Development Effectiveness Framework (document GN-2489), IDB Group operations will incorporate a strong evaluability component; at the same time, the ongoing effort to increase the availability of data in order to facilitate program monitoring and evaluation will remain a core component of the Bank's knowledge agenda in the sector.
- f. Following the guidelines set forth in Vision 2025 (document AB-3266), operations related to innovation, science, and technology must constitute an efficient response to the COVID-19 crisis and promote increased regional integration and digitalization, be an attractive opportunity for smaller companies, promote higher levels of inclusion and empowerment of women, and provide for better responses to the challenges stemming from climate change.
- g. In keeping with the IDB Group's commitment to promoting gender equality, as reaffirmed in Vision 2025, operations in the sector will incorporate gender considerations into their design and implementation. The main areas of action that have been preliminarily identified in this regard are: (i) promoting business development and modernization of SMEs that are led and/or owned by women, thereby facilitating the adoption and use of digital technologies; (ii) boosting women's participation in programs for advanced human capital formation and scientific tracks, especially STEM; and (iii) supporting technological entrepreneurship by women.
- h. IDB Group operations in the sector will address climate challenges by strengthening the capacity of counterparts in designing and implementing science, technology, and innovation policies and programs focused on climate change mitigation and adaptation. For example, guidelines will be provided for the design, evaluation, and monitoring of calls for bids for projects dealing with climate change mitigation and/or adaptation. Demand from beneficiaries will also be stimulated through actions to raise awareness of the impacts of climate change and through the implementation of projects that demonstrate opportunities for climate action. In addition, information will be disseminated on countries' international commitments to transition to a carbon-free economy that is resilient to climate change.
- i. The IDB Group will expand its portfolio of operations that support the productive digital transformation, with a focus on smaller companies. It will carry out interventions for the adoption of digital business solutions, including awareness-raising, technical assistance, and lending activities. It will promote the development of advanced digital talent and strengthen digital support services to SMEs. It will also work to enhance the sector's ICT capabilities, with a view to accelerating the emergence of digital solutions providers in the region. At the same time, it will deepen knowledge on these issues through a research agenda that will seek to answer questions related to: (i) evaluating the impact of interventions to support the digital transformation of businesses and digital talent formation; (ii) the effects of investment in digital technologies and other complementary technologies on productivity over time (short, medium, and long term); (iii) challenges related to cybersecurity, data

protection, and regulation of digital technologies; and (iv) possible synergies between emerging digital technologies and decarbonization.

- j. IDB Group operations in the innovation, science, and technology sector will include activities and resources for more effectively communicating their results and impacts.

B. Line of action 2: Boost investment in key public goods for innovation

- 5.4 The main objective of these lines of action is for governments to devote **more resources to public goods** that are necessary as inputs for innovation, such as shared infrastructure, foundational and applied knowledge, and advanced human capital. In addition, the lines of action seek **greater participation by the State in demanding** technology-based solutions for its own activities.
- 5.5 **Increase efforts on scientific infrastructure and research.** Financing needs to be provided for scientific research, both that resulting from curiosity and applied research, that furthers peer-reviewed collaborative, multidisciplinary work of excellence. Some of this support needs to be provided neutrally and/or without applied purposes, while a growing part is linked to the challenges or interests of society and the productive sector. This must be consistent with greater investment in medium-sized and large equipment needed for those activities, seeking shared use of this equipment.
- 5.6 **Increase support for technological institutes and certification institutions.** Support capacity to generate pertinent technological information for innovation activities and/or sectors that, because of their nature, are not financed by the private sector. Those activities should include the development and, particularly, the dissemination of the knowledge generated, in order for companies in the region to quickly incorporate and adapt it. In particular, support countries in the region in strengthening their systems of standardization, accreditation, and metrology, especially for activities where traceability and other nonobservable characteristics of the goods and services are key.
- 5.7 **Strengthen the formation of advanced human capital.** Promote scholarship and contingent loan programs for postgraduate studies for outstanding students in domestic and foreign institutions. These programs should not only ensure sound selection mechanisms for scholarship recipients but also have monitoring systems and, particularly, tools for job placement in academia, the public sector and, primarily, the productive sector. Particular attention should be paid to programs focused on STEM fields and on incorporating women, candidates from rural areas, and diverse groups (indigenous, Afro-descendants, persons with disabilities, and the LGBTIQ+ community, among others).
- 5.8 **Promote scientific and technological ventures, as well as mechanisms for supporting STI based on challenges, competitions, and awards.** Promote ventures with technically validated proposals that are seeking commercial viability. Couple those actions with support for holding competitions based on challenges and awards aimed at providing a scientific or technological solution to problems or

addressing relevant opportunities for existing productive sectors or those needed for new production activities.⁷²

C. Line of action 3: Foster an enabling environment for private investment in innovation and connectivity

- 5.9 Proposals under this line of action must seek to **increase investment in innovation** by companies in the region. The mechanism for doing this is, on the one hand, to increase incentives for companies to do STI work. On the other, it is to have sufficient information for better decision-making, seeking to reduce uncertainties and support directing their investments to STI activities.
- 5.10 **The region needs to promote mechanisms for improving access to relevant information needed for investment decisions.** To that end, platforms, information systems, and other digital mechanisms aimed at delivering information on recent technological advances and the different relevant technologies available for the countries' productive and service sectors need to be generated. Likewise, support is needed for creating forward-looking spaces where, by creating scenarios, future stages of the national and international economy can be simulated and, based on that, companies can thus make more informed STI investment decisions.⁷³
- 5.11 **Countries in the region need to promote and strengthen their competition policies.** To do so, they must pass or improve laws and regulations sanctioning anti-competitive practices, collusion, or the creation of artificial barriers to entry for new competitors, together with regulatory mechanisms, which can be tested through sandboxes, needed for consumers to have more information on the characteristics of the different goods and services the economy offers.
- 5.12 **The region needs to promote innovative public procurement mechanisms.** To that end, governments in the region need to support regulation of public demand mechanisms for innovative solutions by the public sector. In particular, they must support building capacity to structure functional bidding associated with government needs for which there is no predetermined technical solution, together with regulatory mechanisms on property rights and beneficial interest associated with those solutions.
- 5.13 **Strengthening the business climate.** Support the establishment of a broad set of practices, rules, regulations, and laws that enable science, technology, and innovation activities to flourish in companies and in relation to other agents in the National Innovation System. Support enabling the public and private institutional structure underlying these measures to evolve in a stable, consistent manner over time, offering the incentives and inducements needed for agents to be able to do their STI work in the countries in the region.
- 5.14 **Support connectivity and innovation initiatives in the private sector.** On the one hand, foster the deployment of advanced telecommunications networks by the private sector and through public-private partnerships, for faster, more inclusive

⁷² The challenges to be considered include those related to climate change, decarbonization, digitalization, inclusion, and others as determined by each country to be relevant in their growth and development strategies (Mazzucato and Penna, 2020).

⁷³ Based on the foregoing, at least an adequate digital infrastructure is needed, as outlined in the second Update of the Institutional Strategy 2020-2023 (document AB-3190-2) and the Digital Transformation Action Framework, IDB Group 2021.

access to broadband throughout the region. On the other, support the business sector in initiatives aimed at boosting connectivity and promoting the digital transformation of traditional companies and SMEs through financial support and advisory services to the private sector in the region. Finance companies with innovative business models, directly and through funds, and support them with advisory services, to implement technological advances that enhance production processes or service delivery and boost competitiveness. Also, promote the financing of production and foreign trade chains that leverage innovative technologies to democratize financing for SMEs. Through a mix of products and services, the IDB, IDB Lab, and IDB Invest can support a continuation of the lifecycle of companies, from startup through to scale, to promote impact innovations (see paragraph 4.24).

D. Line of action 4: Promote actions to fix market failures limiting business innovation

- 5.15 There is a wide range of market failures in innovation activities that impede higher levels of STI in the countries of the region. The main objective of the proposals presented below is to **increase public resources complementing private efforts** in innovation activities where market incentives are insufficient or nonexistent.
- 5.16 **Promote financial and nonfinancial stimulus mechanisms for R&D activities in companies.** Support the implementation of subsidies, particularly matching grants aimed at promoting STI activities in companies. Alongside this, promote tax credits for R&D work in larger companies, yielding a greater benefit if that work is done in connection with other agents, particularly universities and research centers. Promote financing mechanisms through loans and/or government guarantees for STI activities in companies, by developing platforms that allow for swift, complementary financial and technical evaluations within financial institutions.
- 5.17 **Increase support for technological extensionism and foster the adoption of technology.** Promote the implementation of mechanisms for disseminating technology packages that have already been technically validated and are aimed at improving production practices and/or service proposals in sectors with a high density of smaller companies. Use financial instruments, such as guarantees and loans, to provide support aimed at enabling firms to implement the infrastructure and put in place the necessary competencies to incorporate, adopt, and transform existing technologies within companies or in connection with local technology providers.
- 5.18 **Financing centers of excellence and technology consortia.** Support research centers or groups seeking to make STI work relevant by directing it at problems or opportunities in productive sectors or issues of national interest. Likewise, cofinance technology consortia—legally established as public or private nonprofits—aimed at middle-stage R&D activities pursuing the relevant technical viability for the corresponding productive sector.
- 5.19 **Increase support for incubators and accelerators and financing of venture capital funds in STI areas.** Promote the building of incubation capacities and the acceleration of new ventures, ensuring that collaboration networks are built and maintained and technical support and ties with domestic and foreign sources of

- early financing are developed. To complement this, aim to support the development of a supply of venture capital funds to supplement private investors, aimed at financing science and technology-based startups in the early rounds of financing.
- 5.20 **Promote increased technology transfer.** Support the development of infrastructure, training, practices, and regulations, particularly for intellectual property, for liaison and technology transfer units in universities, scientific centers, public research institutes, and other packaged knowledge providers for productive sectors and society as a whole. For this process to flow better, instruments need to be promoted to develop skills and competencies consistent with the STI challenges in both the knowledge providers and companies seeking that knowledge.
- 5.21 **Support cluster formation and the development of suppliers and value chains.** Promote the development of production and/or service clusters aimed at taking advantage of the benefits of the complementarities of physical proximity, shared use of assets and enabling infrastructure, all considering the opportunities the territories provide.⁷⁴ Also support the implementation and startup of programs seeking to lower transaction and information costs among the different links in the production and service chains in countries in the region.
- E. Line of action 5: Strengthen key institutions to drive innovation**
- 5.22 Build the capacity of the makers and executors of policies aimed at increasing STI activity in the region, both in the public and private arenas. More active State participation in promoting this activity requires that the State be better prepared for such work. For this, an institutional structure needs to be in place that prevents failures of the State and seeks to **resolve coordination problems** between the different parties involved in innovation, such as a mechanism for reconciling growth, social inclusion, and sustainability.
- 5.23 **Build institutional capacity.** Support capacity-building among the makers and implementers of public policies supporting innovation, including councils, ministries and agencies, taking into account the heterogeneity across the different countries in the region. Also strengthen the actors connecting the National Innovation System, such as technology transfer offices and venture or risk capital fund administrators, since they do not connect automatically. This goes hand in hand with support for the participation of new actors in the National Innovation System, such as development banks, funds of funds, and angel investors. Likewise, countries that consider strategies based on challenges and missions will need to have the necessary competencies at all levels of the public and private institutional framework for those purposes.
- 5.24 **Promote challenge- and mission-based STI strategies.** Support the development of innovation strategies aimed at solving far-reaching social, environmental, or production problems that have a major impact on society.⁷⁵ This will require implementing sector or thematic funds along with building the capacity

⁷⁴ These activities can complement those stemming from promotion with actors outside the countries' borders discussed in the Integration and Trade Sector Framework Document (document GN-2715-11), as well as through the formation of talent through bootcamp-style programs with proven success.

⁷⁵ One example is aligning low-carbon economic policies with innovation policies aimed at carbon neutrality (MCTCI, 2021).

and institutional structure needed to avoid capture and dynamic inconsistency, ensuring there are transparency, monitoring and proposal management mechanisms using a portfolio and risk diversification approach.

- 5.25 **Ensure the promotion of intellectual property.** Strengthen the public institutional framework related to protecting intellectual property rights in their regulatory and enforcement dimensions. In terms of regulations, while most countries in the region have made significant updates to their legal frameworks in recent decades, there are still areas where regulation is needed for intellectual property modalities that are especially relevant for economies in the region, e.g. modalities for geographical indications, traditional specialties, and the protection of ancestral knowledge, among others. There are also regulatory areas of conflict that need to be addressed, such as that between patent legislation and laws protecting breeders of plant varieties. In terms of enforcement, the region's knowledge markets continue to be highly informal, which must be addressed by modern antipiracy laws that include categories such as denunciation. An institutional structure is also required that allows for fluid access to information on intellectual property, timely registration, and a credible system of rights and duties aimed at encouraging the development of new knowledge-based value propositions. At the same time, safeguard due access to knowledge in the public domain for different actors in the National Innovation System.

F. Line of action 6: Knowledge agenda

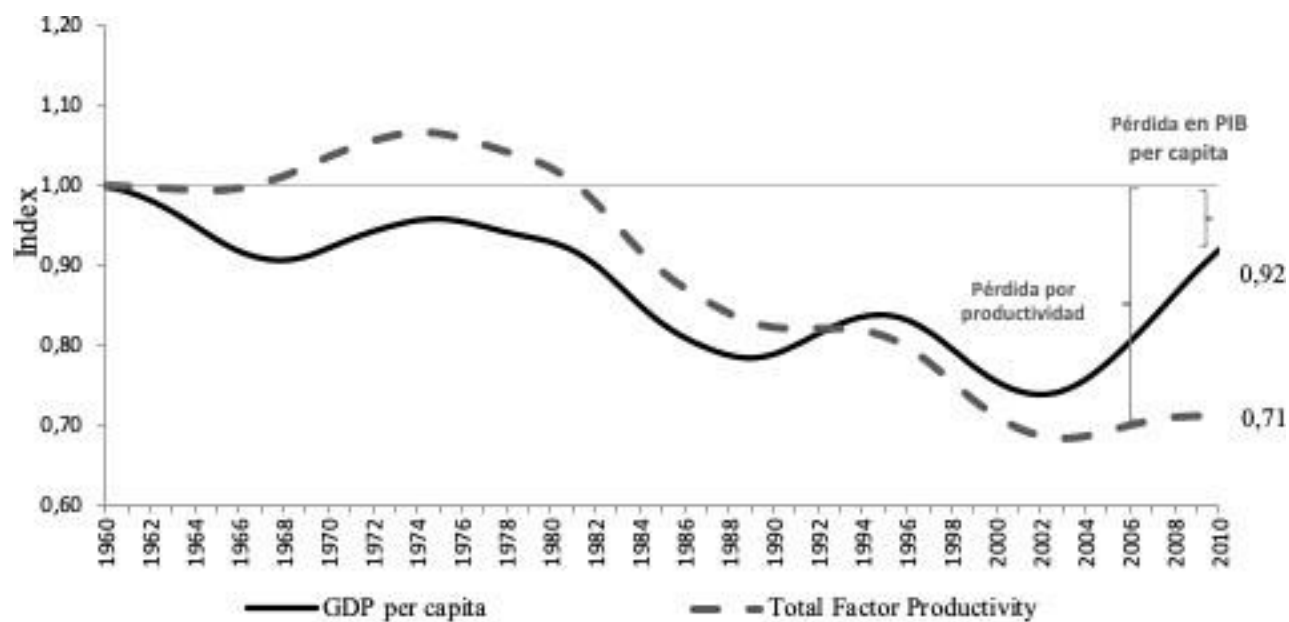
- 5.26 **Under the five preceding lines of action, the IDB Group will seek to increase knowledge on the effectiveness of the programs and policies it supports.** For this, the IDB Group will first support the design and implementation of the mechanisms needed to have updated information on the efforts all the countries in the region are making on innovation, science, and technology activities. To that end, it will benefit from opportunities offered by the digital revolution for generating innovation indicators in real time using public information shared by companies on social media. This will make it possible to have information practically in real time for countries for which data are already available and to extend these indicators to those countries for which data is not yet available (Bertschek and Kesler, 2018). Then, the IDB Group will promote open regional dialogue with public and private sector participation to help guide its work in these areas. To nourish that dialogue, the IDB Group will analyze the operation, cost-effectiveness, and impact of projects, using the most rigorous methodologies possible. It will also seek to develop innovative, experimental proposals so as to have a better understanding of the effects and transmission channels of public support on innovation activities in companies in the region. The results of these analyses will be disseminated within and outside the countries in which the projects are carried out, with a view to sharing knowledge and experience among the Latin American and Caribbean countries.
- 5.27 **In line with the foregoing, the IDB Group will develop a knowledge agenda on a series of relevant issues on which there is little information.** These issues include the following: the effect of competition policies on innovation in countries of the region; the evaluation of innovative public procurement mechanisms and the effect of demonstrations on the innovation dynamics of companies; assessment of the impact of technology institutes, technology parks, and science and technology centers on scientific output and on links with

productive companies; the reasons for the scant supply of researchers involved in STI activities; the importance of dynamic entrepreneurship for innovation; the effect of gender asymmetries on all mechanisms for supporting STI activities; the effect of financial and nonfinancial instruments to mitigate market failures. What's more, across the board, it will seek to continue consolidating estimates of the effects of support for innovation, science, and technology, particularly as regards synchronizing policies and institutional challenges in the region. Lastly, the IDB Group will be attentive to the emergence of new, disruptive phenomena (e.g. technological, scientific, or productive ones, such as bioeconomy and the blue economy, among others associated with the countries' collective challenges) to include them in a timely manner in its knowledge agenda and to inform its dialogue with member countries.

ANNEX FIGURES AND TABLES

Figure 1. Evolution of total factor productivity (TFP) and per capita GDP for a typical LAC country relative to the United States (1960=1)

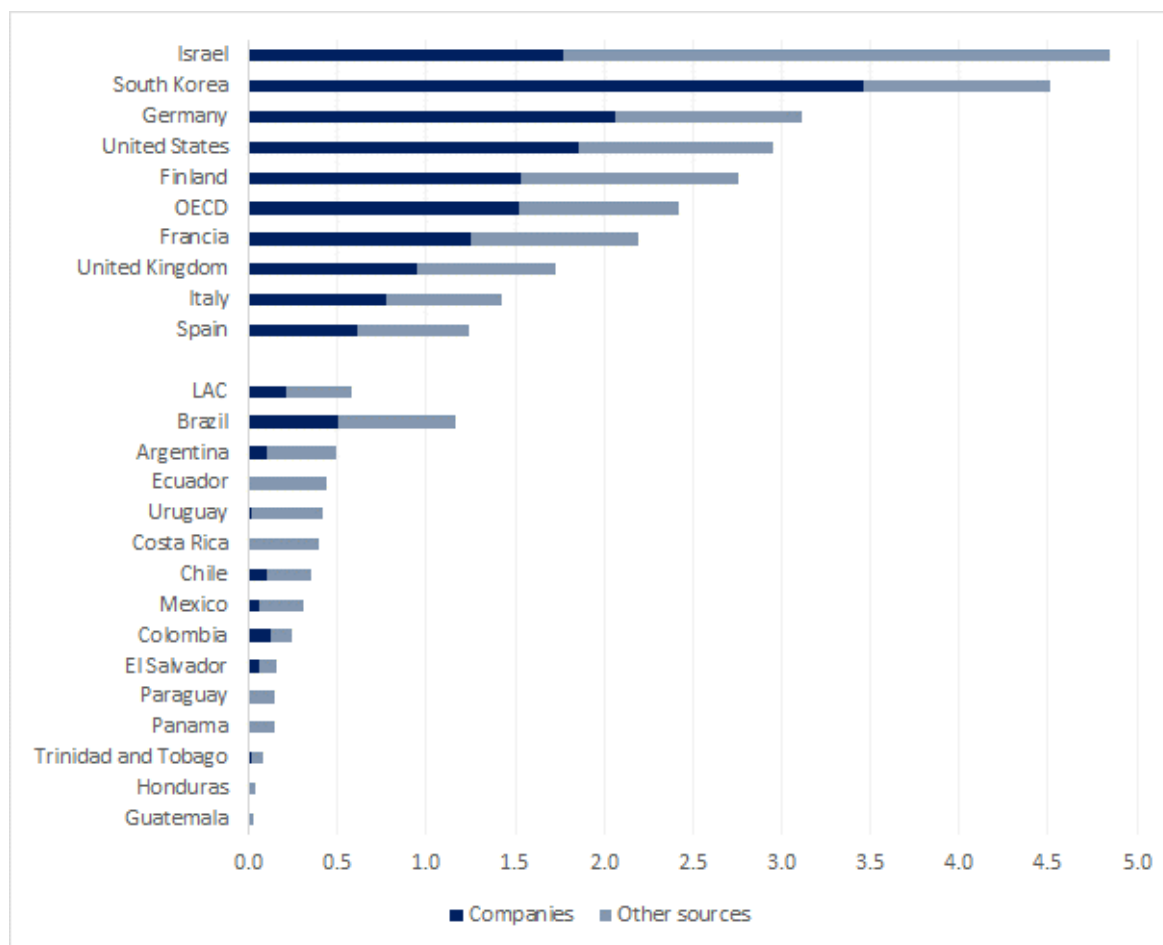
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Source: Crespi, Fernández-Arias, Stein (2014).

Figure 2. R&D spending as a percentage of GDP and source of financing

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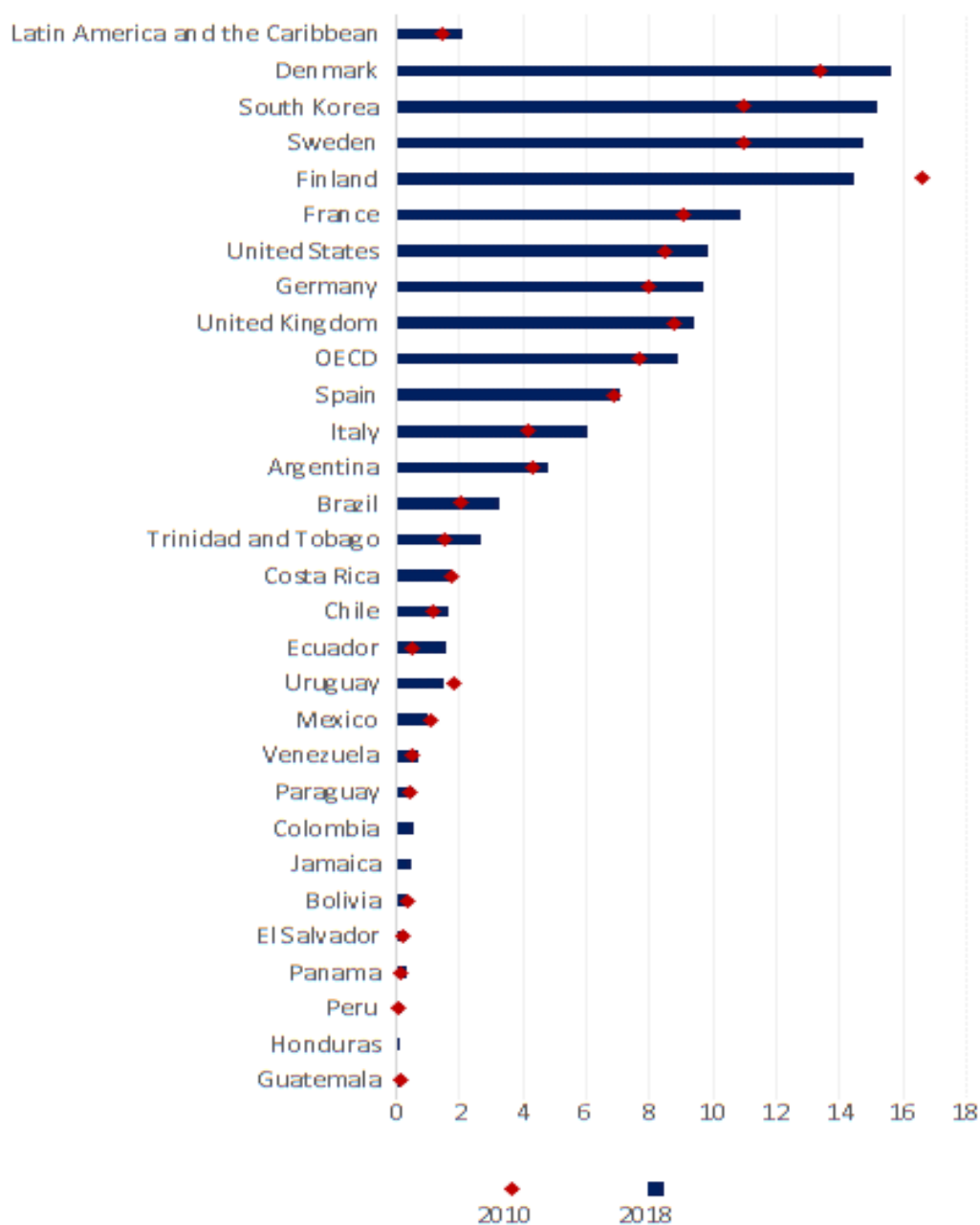


Source: OECD, [MSTI](#), and [RICYT](#).

Notes: The data are from 2018 or the latest year available: 2017 for Colombia and Panama, and 2014 for Ecuador.

Figure 3. Researchers per 1,000 persons in the labor force

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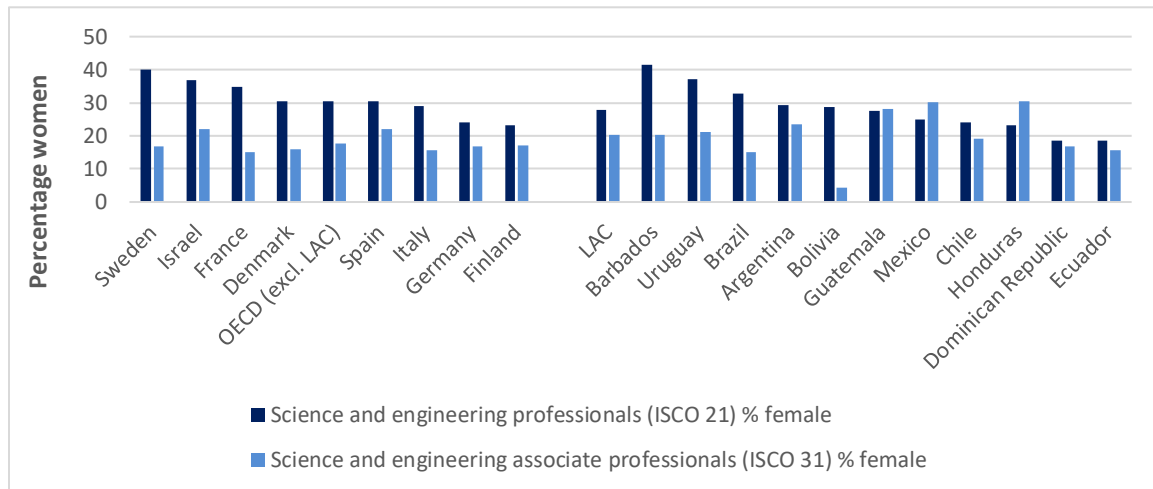


Source: OECD, [MSTI](#), and [RICYT](#).

Notes: The data are from 2018 or the latest year available: 2017 for Colombia, Honduras, Jamaica, and Panama; 2016 for Venezuela; 2015 for Brazil and 2014 for Bolivia and Ecuador. Available data closest to 2010 are for 2009 for Brazil and 2011 for Paraguay.

Figure 3a. Professionals associated with science and engineering in 2020 (or most recent year), percentage women

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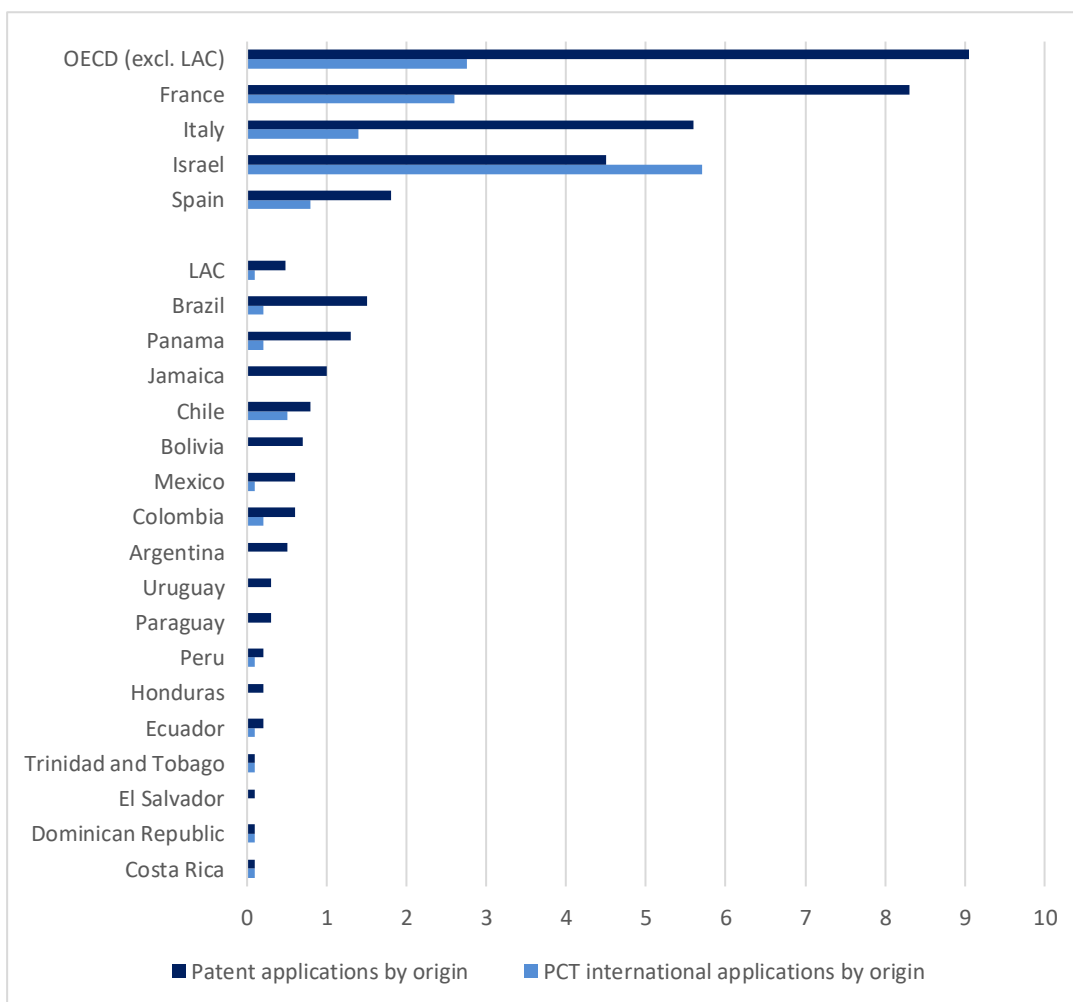


Source: ILO Stat.

Notes: The data for Barbados, Guatemala, Honduras, and Uruguay are from 2019, and the data for Chile are from 2017. The regional averages are simple averages of the countries for which data are available. The OECD average excludes data from Latin American and Caribbean countries and certain other countries; there are no data for Australia, Canada, Greece, Japan, South Korea, New Zealand, and Turkey. The data for the United Kingdom is from 2019 and for Israel from 2017. The cutoff year for the data presented is 2017.

Figure 4. Patent applications by origin/bn PPP\$ GDP, 2018 and Patent Cooperation Treaty (PCT) international applications by origin/bn PPP\$ PIB, 2019

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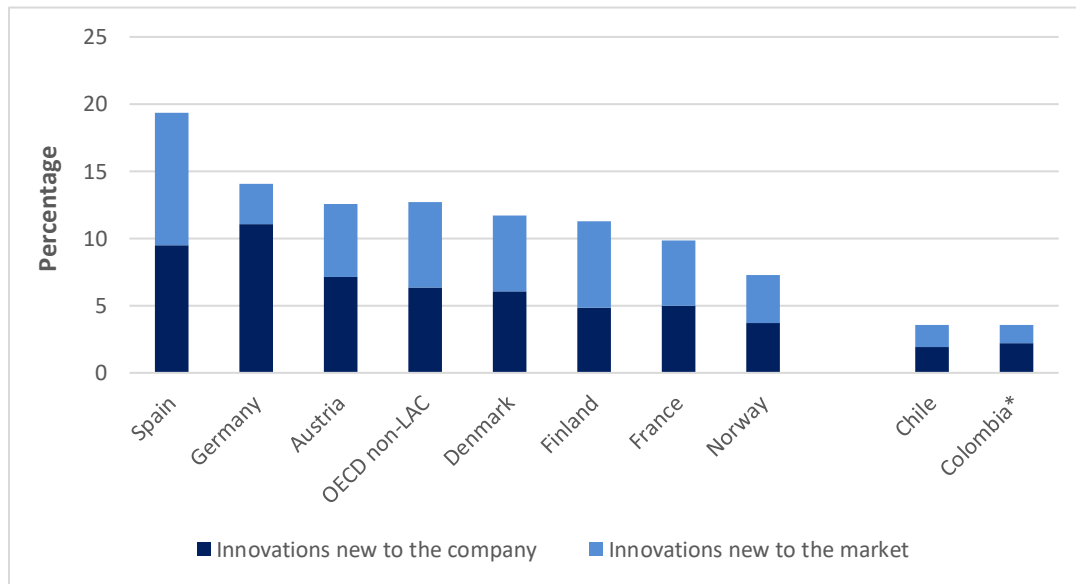


Source: Global Innovation Index, 2020. Original source: World Intellectual Property Organization (WIPO).

Notes: Data for patent applications by origin are from 2018 and for PCT international applications by origin from 2019. The averages are the simple average of the value of countries in the region. The OECD average excludes LAC countries.

Figure 5. Sales of new or significantly improved products, by type of innovation, as a percentage of total sales, 2016 or latest year

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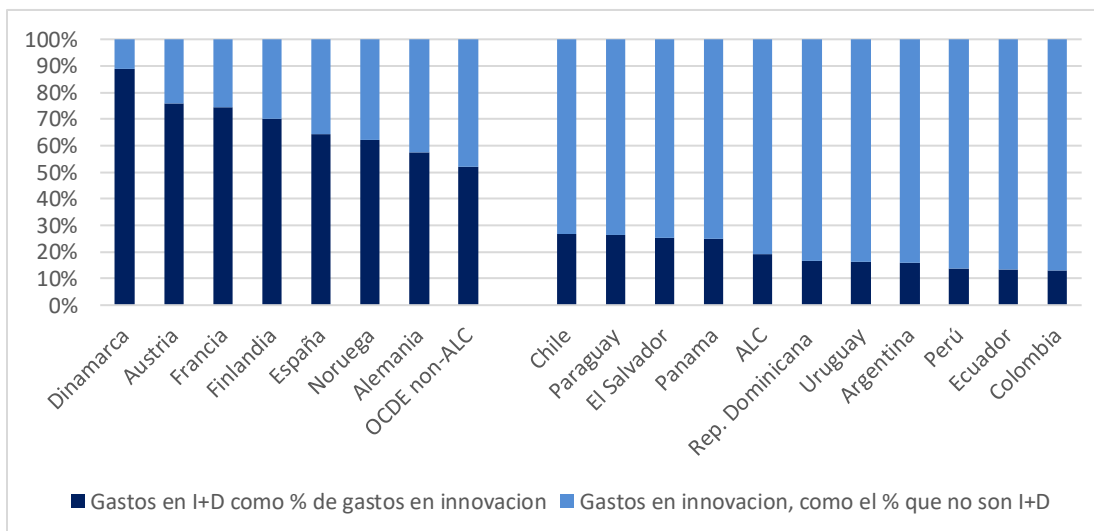


Source(s): OECD, 2019, Innovation indicators: <https://www.oecd.org/innovation/inno-stats.htm#indicators>. Original sources: Argentina, the National Innovation and Employment Dynamics Survey (2014-2016); Chile, the Tenth Innovation Survey (2015-2016); Colombia, the Survey on Development and Technological Innovation in the Manufacturing Sector (2015-2016). The source for the majority of the European countries is the Community Innovation Survey (2014-2016).

Notes: The data from Colombia are only for the manufacturing sector. The OECD average is the simple average and excludes the Latin American countries and the following countries that do not have data for this indicator: Australia, Iceland, South Korea, New Zealand, Switzerland, Turkey, and the United States.

Figure 6. R&D spending by companies as a percentage of total spending on innovation, 2016 or latest year

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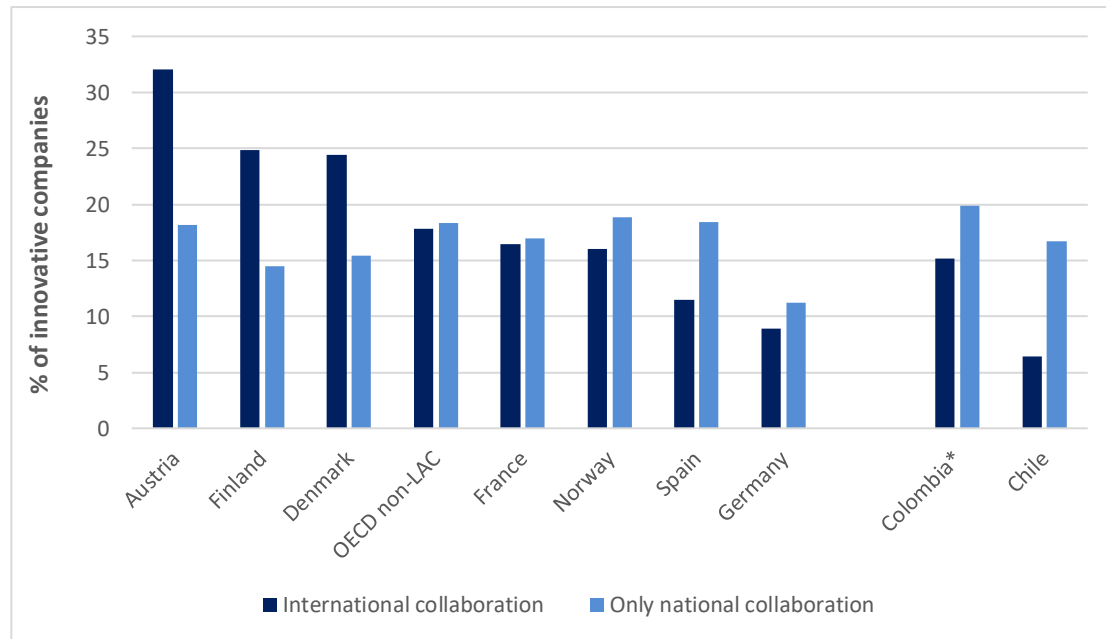
Source(s): OECD, 2019, Innovation indicators: <https://www.oecd.org/innovation/inno-stats.htm#indicators> and Innovation Surveys in Latin America (LAIS).

Original sources: Innovation surveys in Latin America and the Caribbean: Argentina (2016), Chile (2018), Colombia (2019), Dominican Republic (2009), Ecuador (2014), El Salvador (2012), Panama (2013), Paraguay (2015), Peru (2017), and Uruguay (2015); the source for the majority of the European countries is the Community Innovation Survey (2014-2016).

Notes: The OECD average is the simple average and excludes the Latin American countries and the following countries that do not have data for this indicator: Australia, Iceland, Japan, Netherlands, South Korea, Switzerland, Turkey, United States and United Kingdom. The R&D data from the Latin American and Caribbean innovation surveys combine domestic and foreign R&D.

Figure 7. Percentage of companies active in innovation of products and/or processes that cooperate on innovation activities with national or international collaboration, 2016 or latest year

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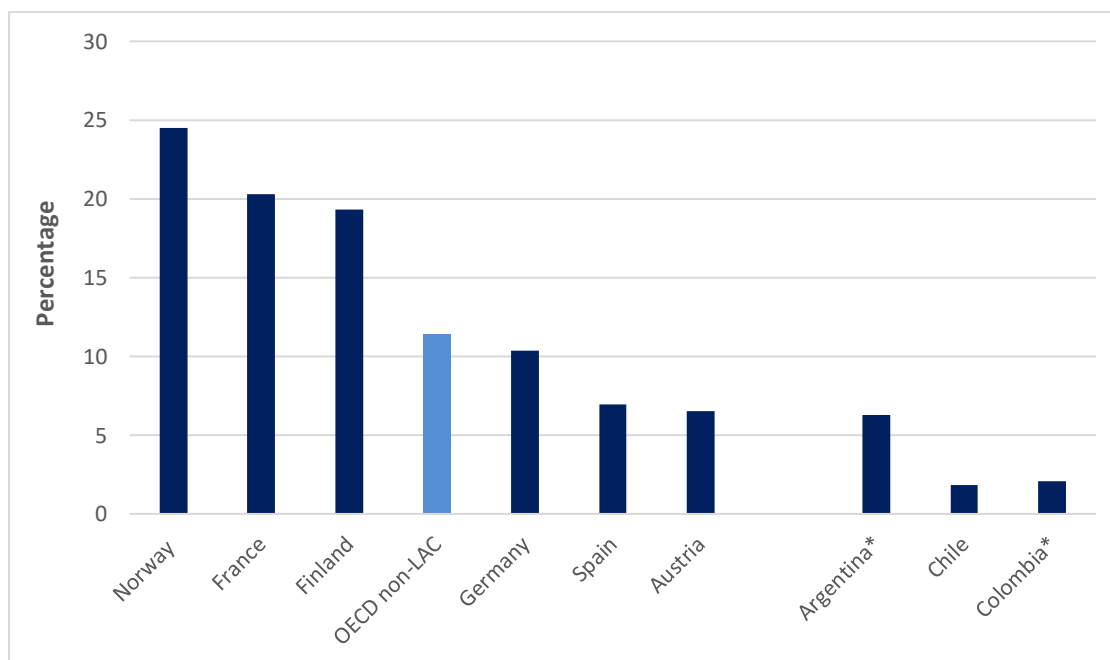


Source(s): OECD, 2019, Innovation indicators: <https://www.oecd.org/innovation/inno-stats.htm#indicators>.
Original sources: Argentina: National Innovation and Employment Dynamics Survey (2014-2016); Chile: the Tenth Innovation Survey (2015-2016); Colombia, the Survey on Development and Technological Innovation in the Manufacturing Sector (2015-2016); the source for the majority of the European countries is the Community Innovation Survey (2014-2016).

Notes: Product and process innovation includes: innovation product/process or activities under way/abandoned, regardless of the organizational or marketing innovation. The data for Colombia are only for the manufacturing sector. The OECD average is the simple average, excluding the Latin American countries and the following countries that do not have data for this indicator: Switzerland and Luxembourg, and in the case of international collaboration: Slovenia.

Figure 8. Companies receiving public support for innovation as a percentage of companies surveyed, 2016 or latest year

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Source(s): OECD, 2019, Innovation indicators: <https://www.oecd.org/innovation/inno-stats.htm#indicators>. Original sources: Argentina, the National Innovation and Employment Dynamics Survey (2014-2016); Chile, the Tenth Innovation Survey (2015-2016); and Colombia, the Survey on Development and Technological Innovation in the Manufacturing Sector (2015-2016); the source for the majority of the European countries is the Community Innovation Survey (2014-2016).

Notes: The data for Argentina and Colombia are only for the manufacturing sector. The OECD average is the simple average, excluding the Latin American countries and the following countries that do not have data for this indicator: Austria, Denmark, Ireland, Iceland, South Korea, New Zealand, and United Kingdom.

Table 1. Policy objectives to address the lack of private incentives

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Lack of private incentives		
More competition	The State as a seeker of innovation	Disseminating experiences
<p>The policy objective here is to implement mechanisms that increase the level of competition that drives companies to generate innovative value propositions. Schumpeter's argument for creative destruction is based on the idea that competitive pressure pushes companies to try to escape from that competition. By investing in STI activities, a firm can potentially achieve this differentiation, which would be temporarily rewarded by enjoying greater market power to achieve such differentiation (Schumpeter, 1934). This conjecture is supported by the evidence, whereby it is observed that markets with more competitive pressure are associated with more efforts to innovate. Conversely stated, in less competitive markets, it is observed that efforts are not aimed at innovation but rather at maintaining high barriers to entry so as to avoid a higher level of competition (Cohen and Levin, 1989; Sutton, 1998).</p>	<p>This policy objective is associated with structuring and increasing the State's role as a seeker of innovative solutions, meaning a set of methodologies and regulations that resolve the problem of coordinating public demand for problem-solving with the supply of private solutions. This goes beyond open innovation, as it includes scaling, and can fall into two types: (i) commercial public procurement of innovation (PPI), which is procurement where the contracting authorities serve as the first customer for innovative goods or services that are not yet widely available, and which may include evidence of conformity or validation; and (ii) pre-commercial public procurement (PCP), which is procurement of R&D services that involves sharing risks and benefits under market conditions, as well as phased competitive development, with the procured R&D services clearly separated from the use of commercial quantities of final products (Georghiou et al., 2014).</p>	<p>Disseminating experiences of innovation practices and processes within a company and with other participants is part of this policy objective. In particular, in contexts where the level of local innovation is low, learning from the experiences of those who have already gone through or experienced the process, as well as learning about international good practices for STI activities, are valuable and relevant sources for adopting internal practices for these activities. Policy instruments that are aimed at collecting and disseminating these practices can be very efficient transfer mechanisms, as well as tools for structuring and standardizing forms of innovation that can be readily adapted by companies, especially smaller ones.</p>

Table 2. Policy objectives to address underinvestment in public actions

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Underinvestment in public actions		
Support for research	Regulations and standards	Business R&D
<p>This has been one of the traditional objectives of policies promoting STI. It aims to increase support for scientific research, especially partnership-based research. The knowledge that arises from formal scientific research is at the heart of the innovative process and, without it, it would be impossible to develop new technological or innovative ideas. In both the linear and systemic models of innovation (Kline and Rosenberg, 1986), innovation relies on advances in knowledge made at universities or in research groups. The increase in the development of scientific and technological infrastructure is complementary to this objective. Research laboratories, as well as pilot-testing centers and other shared use spaces (science, technology, and digital parks) are important venues where basic knowledge is applied and applied knowledge is generated to make it available to companies and society to address their demands for innovation. The low observed levels of such efforts in the region's countries warrants increasing their development, with both public and private contributions.</p>	<p>According to national innovation surveys in the region, one of the main objectives of innovation is compliance with relevant sector regulations and standards by companies (Crespi et al., 2021). Thus, one relevant policy objective is to ensure the establishment of regulations and standards aimed at improving the environmental, health, digital, and information welfare governing business activities in the region. This not only seeks to enhance the quality of life of the inhabitants of a city or country, but also promotes STI activities aimed at compliance with these regulations and the establishment of relevant standards for each sector.</p>	<p>Information asymmetries and a lack of knowledge regarding the benefits of innovation are the context driving companies to experience the development of these activities and their potential returns. Thus, supporting the development of R&D activities within companies has been one of the most recognized objectives in the area of promoting STI (Bloom et al., 2019). Likewise, the inability to take ownership of all the economic benefits that developing new knowledge may have within companies or jointly with research centers or universities inhibits greater effort on these activities by companies. Therefore, the collaborative promotion of R&D activities among companies and other agents of STI also represents a fundamental policy objective for resolving these market failures.</p>

Table 2 (continued). Policy objectives to address underinvestment in public actions

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Underinvestment in public actions		
Training	Extensionism and transfer	Early-stage financing
<p>STI activities within companies require a trained workforce. This not only includes scientists, but also specialists, technicians, and engineers who support the different stages of the innovation process within companies. Financing by firms for development of these types of skills and competencies could be unattractive due to the problems of intangibility of assets or the lack of information on how to get them. This gives rise to policy objectives aimed at promoting training and education at the various levels of the workforce, in line with the companies' STI efforts and strategies. This also applies to the personnel working in other areas, such as the government or universities and research centers.</p>	<p>There is evidence that companies—especially smaller companies—lack access to the best practices and technologies that could have a real impact on their productivity and economic performance. The search costs or information asymmetries that decision-makers at these companies may have warrant public action to try to overcome these shortcomings. The supply of solutions is unknown, there is a lack of trust in their benefits, or the cost of acquiring or adopting such solutions may simply be too high. Supporting the adoption of new production practices, such as the development of new business models and the adaptation of practices and technologies to the local context appear as policy objectives that have been broadly promoted in the world and the region (IDB, 2014).</p>	<p>The evidence reviewed shows not only a low number of companies that innovate in the region, but also no observed new group of science and technology-based companies (IDB, 2020). This latter type of innovative startup faces two problems from a financing viewpoint: the traditional failure associated with the uncertainty about whether the value proposition will ultimately end up yielding a return. But they also face the uncertainty associated with the technical viability of their innovative proposal, which must be addressed in order to be able to continue with the following stages of the startup. Considering that this type of startup also creates better quality jobs gives rise to the policy objective of promoting the development of new early-stage financing mechanisms for science and technology-based companies.</p>

Table 3. Policy objectives to address the weak public institutional framework

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Weak public institutional framework		
Prevent government failures	Protect intellectual property	Greater participation by women
<p>One of the characteristics of the efforts in STI is their intangibility (knowledge) and that the expression of their results is not immediate and may require a significant amount of time (Benavente et al., 2005). At the same time, innovation and associated activities are not supported by a single unit in the public institutional framework, but rather are scattered across various ministries and agencies, both national and regional (Angelelli and Suaznabar, 2019). All these characteristics contribute to or are manifestations of the so-called failures of the State—dynamic inconsistency, problems of agency and capture—for which the lack of an institutional framework that can prevent them inhibits greater efforts in STI. The evidence suggest that there have been many cases of a lack of consistency of policies through the governments, manifestations of problems of agency, such as, for example, the political responsibility of moving forward with public STI efforts, and the spaces for capture that STI promotion policies have had (CNID, 2008). Thus, promoting the strengthening of the institutional framework can help avoid these failures of the State.</p>	<p>The rules of the game associated with the motivation for developing STI activities include the protection of intellectual property rights. Intellectual property is one of the mechanisms that enable the resolution of problems of appropriability stemming from the nature of knowledge as a quasi-public good. A good patent law and proper payment for the use of property rights create proper incentives for innovation (Hall, 2010). However, as Schumpeter mentioned a century ago, an overly strict intellectual property law can also inhibit the mechanisms that disseminate knowledge through society, hindering a higher aggregate level of development of STI activities fueled precisely by such open knowledge (Schumpeter, 1934; Boldrin and Levin, 2006). Pushing policies that protect intellectual property but allow a fluid system of dissemination of open knowledge is a policy objective that can help increase the low levels of innovation in the region's countries.</p>	<p>There is recent evidence that the formation of technological research and development groups with a balanced participation of men and women produces better results than groups made up solely of people of the same gender (Grazzi, 2019). However, it is known that the process whereby such groups are formed, and in general, a greater participation by women in STI do not occur spontaneously. The indicators show low participation by women in these activities in the region, with certain exceptions, such as in Argentina (Olivari et al., 2020). Seeking greater participation by women in the entire innovation chain is thus a very relevant policy objective, not only because of its documented effects on productivity and performance in STI, but also for reasons of justice.</p>

Table 4. Policy instruments

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[\[Return to main document, paragraph 3.2\]](#)

Private incentives		Public actions due to market failures		Institutional framework	
Supply	Demand	Supply	Demand	Supply	Demand
Forward-looking	Competition policies	Support for scientific research	Regulations, rules, and standards	Innovation climate	Promotion of intellectual property
Information dissemination	Innovative public procurement	Research infrastructure	Certifications		Sector strategies
Demonstrations		Technological institutes	Science-technology challenges/ competitions		
		STEM scholarships	R&D sector funds		
		R&D subsidies	Tax incentives and adoption guarantees		
		Centers of Excellence	Loans and guarantees for adoption		
		Risk capital (seed, angel, venture capital, funds)	Extensionism		
		R&D tax credit			
		Loans and guarantees for technology investments			
		Technology consortia			

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