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Working Paper Series

#2016-058

Innovation system in development: The case of Peru

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UNU-MERIT Working Papers
ISSN 1871-9872

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Innovation System in Development: The Case of Peru

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Abstract

Despite an exceptional economic performance achieved over the last decade, Peru still lags behind other middle-income Latin American economies in terms of per capita income and productivity. The Peruvian economy remains relatively undiversified, largely dependent on natural resources. The national innovation system is under development, weakly integrated, and underfunded, with few incentives for its actors to engage in innovation activities and collaborate with others. This note summarises the current state of innovation in Peru and reviews the capacity of the innovation system to generate new competitive advantages in industry. It briefly discusses policies and policy gaps in research and innovation and benchmarks national innovation competences to other relevant economies, based on available indicators and surveys. Following a sequential approach, a strengthened policy agenda for innovation should tackle fundamental weaknesses of the innovation system and set the basis for its expansion and a better articulation. Examples of policy actions to improve research performance and business innovation are provided. The paper concludes with suggestions for reforming the innovation system and provides examples of policy actions.

Keywords: innovation system, development, Peru, emerging countries and innovation policy

JEL classification: O14, L52, L60, L26, O32, O57

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Acknowledgements: This paper was commissioned as background paper to the World Bank study "*Building on Success - Boosting Productivity for Faster Growth*", which was coordinated by Ekaterina Vostroknutova (GMFDR of the World Bank Group) from the country desk for Chile and Peru, and published in September 2015. The paper hereby contained was produced in 2015 when the author was part of the Trade and Competitiveness Global Practice (World Bank) –Latin America and the Caribbean Region. The views herein expressed are entirely those of the author; they do not necessarily represent the views of the institutions aforementioned.

Introduction

In the last decade, Peru's economic performance has been extraordinary. The economy grew at an average rate of 6.6 percent. Between 2000 and 2010, Peru's GDP increased almost threefold, from US$53.337 billion to US$153.919 billion, which translated into a twofold increase in GDP per capita, from US$2,054 to US$5,224. At the same time, the country made significant gains in social development. Poverty fell from 54.1 percent in 2000 to 25.8 percent in 2012. These achievements were the result of several factors, including macroeconomic stability, improved regulatory frameworks, and trade-related performance. Internal demand also expanded substantially, led by increases in public and private investment and a rise in private consumption.

Yet despite this exceptional performance, the country still lags behind other middle-income Latin American economies in terms of per capita income and productivity. The Peruvian economy remains relatively undiversified, largely dependent on natural resources. While productivity has grown in recent years, it continues to trail leading Latin American countries. The authorities are determined to foster medium and long-term sustainable growth by promoting productivity development and new sources of competitiveness to reduce dependency on primary resources, increase productivity throughout the economy, and generate high-quality employment in the formal sector.

To achieve these objectives, Peru needs to strengthen its national innovation capacity in a broad sense: by increasing learning and technological upgrading of firms and industries, and developing new technological competencies to support its economic transformation. This will require rehabilitating the national innovation system (NIS), modernising its governance and effectiveness, as well as strengthening conditions and incentives for business innovation. Peru has delayed taking actions to address the innovation needs of the economy compared to other middle-income economies in the region and many other emerging economies. The NIS is today underdeveloped, poorly integrated, and underfunded, with few incentives for its actors to engage in innovation activities and collaborate with others.

This note summarises the current state of innovation in Peru and reviews the capacity of the main actors in the innovation systems as well as policies undertaken to foster innovation in Peru. We compare Peru's investment and innovation performance to that of other Latin American and Caribbean (LAC) economies, based on available indicators and surveys. Section 1 provides the rationale and explains why Peru needs to improve its national innovation capacity. Section 2 reviews where Peru stands internationally on several indicators of innovation and technological development and discusses major issues affecting the development and functioning of the NIS and their repercussions for business innovation capacity. Section 3 describes the main actors in the innovation system, the state of business sector innovation, competencies for R&D, and technology transfer in the public research and technology sector, as well as the governance aspects that frame knowledge generation and transfer and industry-science linkages.[1] Section 4 discusses the role of government and reviews recent innovation policy in Peru and compares to it to policies in the region. Conclusions and policy recommendations are presented in Section 5.

[1] This section integrates key messages from the reviews made by UNCTAD (2011) and OECD (2009).

1. The Rationale for Innovation

Innovation is at the heart of creating and sustaining economies' comparative advantages and of raising productivity and economic growth. Innovation is a broad concept that relates not only to the generation of new ideas but also to the process of diffusion and adoption of new knowledge and technologies. According to research and economic history, growth depends on factor accumulation, but is mostly the result of innovation and diffusion of new technological knowledge (Aghion and Howitt, 1997; Romer, 1990).

International experience has repeatedly shown that countries' capacity to create, adopt, and adapt knowledge and technology is critical to their progress in obtaining higher levels of diversification, productivity, income, and societal wellbeing. Innovation is concerned with the creation of radical technologies that are new to markets, as well as the adoption of existing innovations that are new to the local context or at the firm level (incremental innovation), even if its contribution to global knowledge is limited. The latter is particularly important for the process of technological learning and catching up in firms that are lagging far behind the technology frontier.

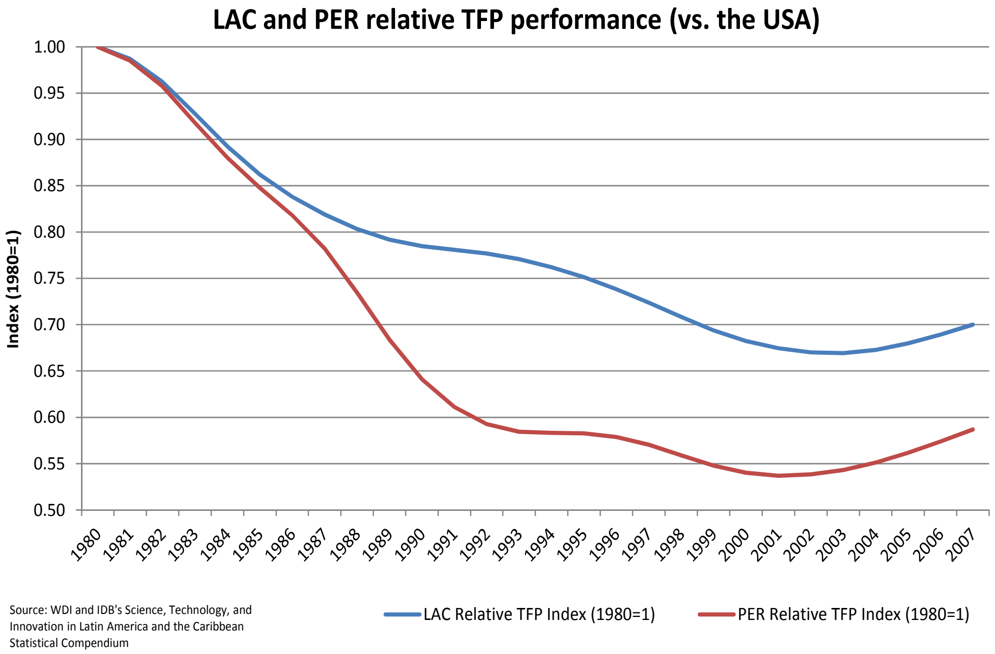
At the firm level, innovation can lead to a more efficient use of resources and new markets. It can create sustainable competitive advantages if conditions for commercialisation, competition, and business development exist and provide sufficient incentives to engage in risky and appropriable investment. Thus, innovation is not an automatic process. It depends not only on the availability of resources and skills, but also on the ability to commercialise new products and services, compete in markets, and appropriate the returns from innovation, among other contextual factors.[2]

There are at least three reasons why innovation needs to be strengthened in Peru:

(1) **To improve productivity and increase value-added in existing industries**. Productivity growth has not kept pace with economic growth. Between 1996 and 2005, total factor productivity (TFP) grew 0.7 percent, while TFP growth was 1.5 percent between 2006 and 2010 and reached 2.2 percent in 2010 (The Conference Board, 2013). Although there are signs of recent improvement in TFP, the gap relative to the United States is higher than the LAC average (Daude and Fernandez-Arias, 2011; IDB, 2011). In 2007 the average TFP of LAC countries was 70 percent of that of the United States, whereas Peru was achieving less than 60 percent (Figure 1). According to Vera (2013), in 2010, TFP in Peru was a third of that of the United States, two thirds of that of Chile, and was only higher than the TFP of five countries in the region—Ecuador, Bolivia, Paraguay, Honduras, and Nicaragua. This aggregate TFP figure masks profound regional and sectoral disparities within the country, reflecting important economic unbalances.

[2] According to the Oslo Manual (OECD, 2005) innovation is the introduction of new or significantly improved products, process, or organizational and business models. These results in turn are driven by investment in innovation capacity. According to the Oslo Manual (OECD, 2005), innovation activity is a broad concept that includes R&D and non-R&D investment. The latter relates to expenditures for the commercialization or implementation of innovations such as the acquisition of machinery and equipment, training, investment in software or hardware (supporting new or improved product or process development), marketing and distribution, technology, and know-how licensing (including licensing or purchase of intellectual property), among others.

Figure 1: Evolution of Peruvian Total Factor Productivity Relative to the United States and the LAC Average



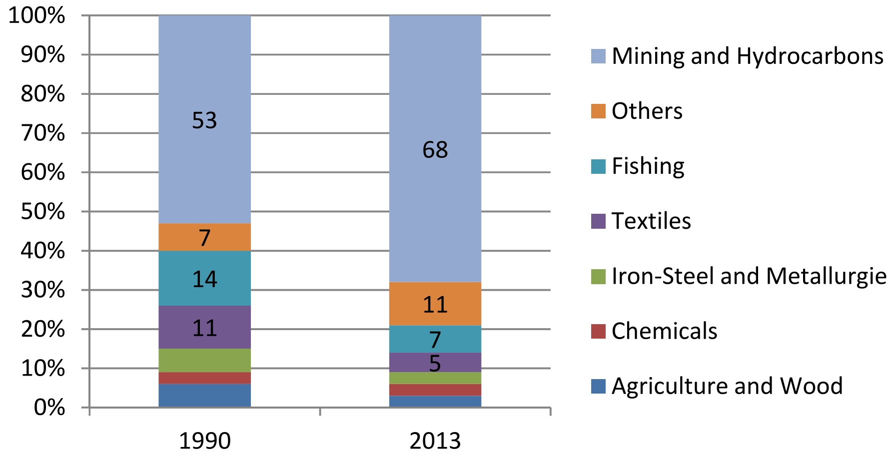
Source: IDB Science, Technology and Innovation in LAC –Statistical Compendium.

(2) **To diversify the economy and create new sources of growth.** Peru's export basket remains heavily tilted toward natural resources, and while non-traditional exports have picked up in the last decade, their level of processing remains low. More than three-quarters of exports are traditional primary products with limited value added; two thirds are mining exports, with gold and copper representing 80 percent of such transactions (Figure 2). This trade performance has benefited from favourable external conditions, in particular, growing demand from China and India for mineral commodities.

(3) **To better address development and social inclusion challenges and improve the impact of policies and public services in order to reduce poverty.** Innovation is crucial to addressing development challenges such as improving the quality and delivery of education and health, providing water sanitation and energy, and preserving the environment through green growth strategies.[3] Despite meaningful advances in poverty reduction and social inclusion, rural poverty is double the national average, and chronic malnutrition afflicts one-third of all children in rural areas.

[3] Innovation also helps improve the quality of public administration through the adoption of new technologies and new organizational models, such as information technologies (IT) and e-governance.

Figure 2: Evolution of the Structure of Exports



Source: MEF (2012) and CONCYTEC- "*Crear Para Crecer*"-Estrategia Nacional de CTI (2014).

Peru's economic structure has not changed in 60 years. This situation compromises economic growth and new advances in social development for the future. Approximately 65 percent of GDP is concentrated in three sectors: services (39.9 percent in 1950 and 39.6 percent in 2012), commerce (14.8 percent in 1950 and 15.3 percent in 2012), and mining (11 percent in 1950 and 9.4 percent in 2012). These industries are characterised by low value added, and, in the case of mining, generate few jobs. Primary sectors contribute 16.6 percent to GDP, while manufacturing contributes only 13 percent. At 63 percent of GDP, the service sector is the largest in the economy.

Peru's dependence on exports of commodities and raw materials makes it vulnerable to fluctuations in international prices. Mining and hydrocarbons as a share of total exports increased from 53 percent ____ to 68 percent of total exports between 1990 and 2012. In 2012, international trade represented 50 percent of GDP, consolidating a steady increase in exports, which has resulted in a trade surplus since 2003. This trend was facilitated by favourable external conditions and growing demand for commodities from China and India. Yet the export sector remains weakly linked with the rest of the productive system. Thus, there are few opportunities for spillovers and growth of domestic firms.

International evidence has shown that countries with more diversified economies and greater value added and technological complexity tend to grow more and develop competitive advantages that are more sustainable over time (Hausmann et al., 2007; Rodrik, 2001, 2006). In fact, most of the difference between Asian and Latin-American countries' productivity performance is explained by differences in their patterns of structural change (McMillan and Rodrik, 2011), with labour moving from low- to high-productivity sectors in Asia, but moving in the opposite direction in Latin America and Africa.

In order to catch up, productive structures must become more diversified and complex. This requires greater use of technology and new knowledge to foster productivity and reduce structural heterogeneity. Historical experience shows that all successful cases of convergence, including China's recent emergence as a new economic power, were associated with the implementation and development of new sectors or business activities. It has been shown empirically that increases in productivity do not derive only from accumulating the same type of capital or producing more of the same goods; rather, they occur when new products and processes emerge and shift the production matrix. Structural change is also fundamental for narrowing the income gap within economies.

Peru is thus at a crossroads in defining its economic future. It could stay dependent on income from natural resources and be subject to significant price instability. Or it could foster strong and inclusive economic growth and transform its economy through diversification and development of more sophisticated service industries. To do so, investment in knowledge, technology adoption, and transfers, and innovation competencies must be increased. This evolution requires more investment in science, technology, and innovation (STI) and a more conducive environment for technology transfer and private investment in innovation.

2. Innovation Competencies and Performance –Where Peru Stands

Peru is an upper-middle-income country with an embryonic national innovation system and an underdeveloped business innovation capacity, which is disconnected from its economic performance and level of development. Its innovation and technological performance lags far behind peer economies within and outside the region, according to several indicators.

Peru has been unable to increase innovation capacity in its public or private sectors, which has hindered opportunities for productivity, growth, and competitiveness. The national innovation system remains underdeveloped, under-funded, and poorly articulated.[4]

As highlighted in several international assessments, one factor that deters Peru's future growth is its weak capacity in research and innovation. This is reflected in its low levels of spending on science and technology (S&T)-–including technology transfer and R&D compared to countries at similar levels of development, e.g., Chile or Colombia. Peru also has an insufficient human capital base for innovation and technological development, few graduates in S&T and engineering, too few researchers and technicians, along with little interaction between the institutional repositories of knowledge, such as universities and research institutes and the users of knowledge in the private sector. It also lacks an innovation culture.

Peru lags behind its regional peers in all science, technology, and innovation indicators. Peru's innovation delay vis-à-vis Chile, Colombia, Argentina, and other emerging economies exists not only in terms of inputs and investment in innovation and knowledge, such as human capital and education, S&T (Table 1), investment, technology adoption, software investment and other intangibles, but also in terms of knowledge and innovation outputs (Table 2).

Several international indicators, including the Global Innovation Index (GII) and the Global Competitiveness Index (GCI), illustrate this underperformance compared to neighbouring countries and peer economies from other regions. According to the GII, Peru ranks as intermediate

[4] Several innovation reviews have been conducted, including by OECD (2009) and UNCTAD (2011).

internationally but substantially lower than Chile, Colombia, Argentina, and Mexico.[5] The major weaknesses detected according to the GII—where Peru scored the lowest—were: (i) a weak capacity to produce knowledge and technology, reflected in its extremely low levels of domestic and international patenting and S&T publications adjusted per GDP; and (ii) a low base for human capital and research.

This weak performance prevails in spite of Peru's improved institutional development and business environment, its booming commodity exports in previous years, and its stronger macro-economic environment. As reported by several assessments, Peru has improved several framework conditions for innovation, especially in infrastructure development, financial market sophistication, and improved regulatory framework for business development, foreign direct investment (FDI) and trade (see for instance the GII (WIPO and INSEAD 2014).

Table 1 provides a summary of key indicators on human capital and knowledge investment. Peru lags behind its peer economies such as Chile, Colombia, and Argentina and leading LAC countries like Brazil and Mexico in educational attainment and quality indicators and in levels of investment in R&D and in new knowledge. The lack of qualified human capital stands as one of the main constraints to productivity development and innovation in Peru (National Innovation Survey, 2012; World Bank Enterprise Survey, 2010). The supply of skills is insufficient, and the quality of education remains poor. Generally, Peru's educational system is underdeveloped in terms of investment and performance at all levels.

Table 1: Human Capital and Knowledge Capabilities

	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Expenditure on Education (percent of GDP)	5.8	5.8	4.5	4.4	5.2	2.8
PISA scales in reading , math, & Science	396.7	402.1	436.3	392.9	417.3	375.1
Tertiary Enrollment, percent Gross	74.8	n/a	74.4	45	27.7	42.6
Graduates in S&E (percent)	13.5	12	19.2	21.5	26.8	n/a
Researchers, headcounts/mn. Pop.	1941.9	1202.8	551.2	346.4	386.4	181.2
R&D (percent of GDP)	0.6	1.2	0.4	0.2	0.4	0.1

Sources: UNESCO Institute for Statistics, UIS online database (2004–13) and OECD Program for International Student Assessment (PISA) (2010–2012) and World Bank Development Indicators. R&D and researchers data for Peru correspond to 2004.

- In terms of government expenditure on education, Peru's level of investment remains below its peer countries and leading LAC economies (Table 1): while Chile and Colombia spend around 4.5 percent of their GDP on education, Argentina and Brazil spend close to 6 percent. In contrast, Peru's expenditures on education represent only 2.8 percent of GDP. In 2014, Peru ranked 115th out of 140 countries in the GII for this indicator. The weak quality of secondary education is reflected in the results of the OECD PISA test

[5] In 2014, Peru achieved the 73th place in the GII out of 142 countries –four places down compared to 2013, when it was 69th. In contrast, Chile ranked 46th (remaining the same as it was in 2013); Colombia was 68th, down from 60th; Argentina was 70th, moving down from 56th place, and Mexico was 66th, falling three places from 63th in 2013.

(2010-2012) for reading, mathematics, and science. Accordingly, Peru ranks 61st out of 65 countries evaluated, with a score of 375.1 points, well behind Chile, with a score of 436.3, Colombia at 392.9, Argentina at 396.7, and others.

- Tertiary enrollment is generally in line with the average in LAC (42 percent) but lags behind the region's leaders, Argentina and Chile, and advanced economies (70 percent on average in OECD countries). Yet the quality of Peru's university system has deteriorated over the years with the emergence of private education providers. The system has suffered from the excessive commercialisation of educational provision and the predominance of short-term considerations in terms of supply and demand.
- Peru also has few S&T university graduates and scientific researchers. Industries repeatedly point to the dearth of engineers and technicians as an important constraint on business performance, innovation, and growth. Although recent statistics indicate that the number of university graduates in engineering is growing, industries highlight the need for experienced personnel, which currently do not exist in Peru for several industries.[6] Only a quarter (around 25 percent) of university students are involved in science and engineering (S&E) careers, and the institutions hosting these career programs often have serious deficiencies in equipment that would fully support quality careers in these domains.
- In terms of technical personnel, according to the Human Resource Development survey conducted by the Ministry of Labour in 2011, 37.6 percent of companies in Peru show difficulties in finding qualified technical personnel. Industries also suffer from a lack of qualified technicians at operating levels, and labour demands in these areas are growing. There is a demand for technical operators in the construction and electricity industries, for ICT technicians, and for technicians in textiles and automobile mechanics.

Peru also falls behind in terms of advanced human capital, that is, doctoral-level scientists in S&T. Peru has 181.2 researchers per million inhabitants, compared to 1941.9 in Argentina, 551 in Chile, 1,200 in Brazil, and 346 in Colombia (Table 1). The Global Competitiveness Index 2012-2013 ranks Peru 120th out of 140 countries in availability of researchers and engineers. These trends are aggravated by a lack of incentives for the young to engage in careers in S&T and a lack of policy incentives and strategy to attract foreign talent to fill demands for innovation skills.

There are no recent statistics available for R&D, but the latest figures, from 2004, indicate that Peru invests 0.1 percent of GDP in S&T, whereas Chile and Colombia invest 0.4 percent and 0.2 percent, respectively. LAC countries in general invest too little in R&D, reaching on average 0.078 percent of GDP compared to OECD and European countries that invest on average about 2.2 percent and 2.5 percent of GDP in R&D, respectively. For countries moving up along the development curve, investing in R&D is necessary for the development of new technological competencies and for

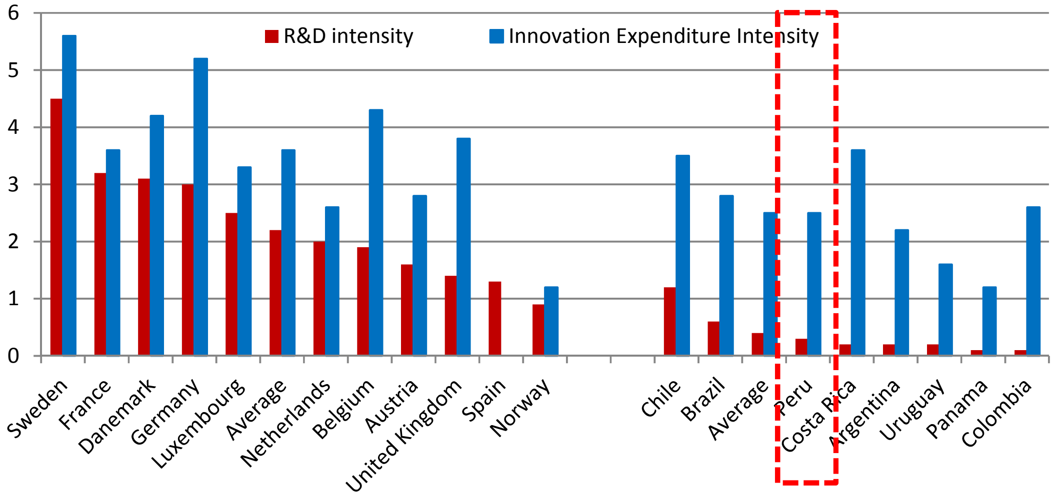
[6] Even mining industries struggle to find qualified personnel. It has been estimated that in order to implement new production projects for the next five years, representing US$50billion, the industry requires 5000 engineers with sufficient experience. According to an industry representative, companies need engineers with at least 15 years of experience and must therefore recruit them from abroad, as currently the supply of engineers in Peru cannot respond to the demand. In metallurgy, firms face important difficulties in finding industrial, mechanical, and electrical engineers as well electronics specialists. In textiles, experts in automation are lacking, according to a representative from the sector.

remaining competitive over the long run. Furthermore, developing an internal R&D capacity eases the process of technology transfer, or absorptive capacity, allowing firms to better identify, absorb, and learn from external technologies and to facilitate their adaptation to the local context (Cohen and Levinthal, 1990; Griffith, et al., 2004; Rostow, 1960). Fundamentally, this capacity enables firms to develop new technological competencies.

In Peru, underdevelopment of knowledge capacity is also reflected at the business level. Not only are R&D efforts low in Peru; they are also concentrated in the public sector through universities and government organisations. In 2004, the last year for which data were available, the business sector represented 29 percent of total investment in R&D, while in Chile and Colombia it reached 40 percent, and today it invests 45 percent of all financing of national R&D.

Private firms, especially small- and medium-size enterprises (SMEs), invest little in innovation, technology adaptation, creation, or adoption, thus losing opportunities for productivity to increase and firms to grow. According to the National Innovation Survey (2012), Peruvian firms invest 2.5 percent of their sales in innovation, and only 0.1 of their sales in R&D, although their peers in Chile, Colombia, and Argentina invest 3.5, 2.6, and 2.2 respectively, of their sales in these activities (see Figure 3). Firms from developed countries invest more: firms from United Kingdom invest 3.8 percent, from the Netherlands, 2.6 percent, and firms from Sweden and Germany invest 5.6 and 5.2 percent, respectively.

Figure 3: Innovation Investment Intensity in Firms



Source: Innovation Surveys based on Data from OECD (2009), IDB (2011) and National Innovation Survey. Data refers to manufacturing industries only.

Peruvian firms are investing less in upfront innovation, such as R&D and related activities, but they are also less engaged in technology transfer activities. Findings from the World Bank Enterprise Survey indicate that Peruvian companies are trailing behind Chilean and Colombian firms in technology adoption, which is part of innovation activity (Table 2):

- In 2010, only 13 percent of Peru's domestic firms have an internationally recognised quality certification, while the average in LAC is 14 percent. In Mexico, Brazil, and Chile, one company in five has this type of certification. Chinese and Malaysian companies display even higher propensities: 53 and 42 percent of firms, respectively, have an international quality certification.[7]

- Only 6 percent of domestic Peruvian companies have technology licensing agreements with foreign companies. The average for LAC is 14 percent, and the worldwide average for domestic companies is 13 percent. Mexico has a rate of 10 percent, Chile, 9 percent. In Brazil, 7 percent of domestic companies have such agreements; while in China 16 percent of domestic firms have entered into international technology licensing agreements.
- In terms of exporting, an important channel for international knowledge transfer and firm learning, Peruvian companies' propensity to export is similar to that of Chilean and Colombian firms: 12.9 percent of domestic companies export, directly or indirectly, while for Chile and Colombia this share is 14 percent and 12 percent, respectively. These propensities are lower than the rate for exporting firms in Argentina and Uruguay, which are 24.6 percent and 18 percent, respectively. Domestic Chinese and Malaysian companies have higher propensities to export: 21 and 50 percent, respectively, of companies in these countries export.[8]
- Opportunities for knowledge transfer from FDI are limited, as reflected in the scant participation in production inputs by multinational companies. In Peru, 52.5 percent of inputs used by foreign companies are locally sourced, whereas in Chile and Colombia, local sourcing by foreign firms reaches 58.6 and 61 percent, respectively. In Peru, in spite of increased FDI in the last years, particularly in energy, mining, communications, manufacturing, and finance, productive linkages with foreign companies remain limited.

[7]According to the ISO Survey, few companies in Peru have implemented quality systems management under ISO standards. In 2012, only 860 companies were certified in ISO 9001, 252 in ISO 14000, and only four were certified in ISO 2700121. These figures are low compared to those in Chile and Colombia. In Chile, 3716 Chilean firms were certified in ISO 9001 and in 1415 firms in ISO-14000. In the same year, 9817 companies in Colombia were certified in ISO-90001 and 945 in ISO-14000.

[8]Exporting is strongly correlated to innovation capacity of the firm—both ex-ante as a preparatory effort for exporting (through firm upgrading) and ex-post though interactions with clients abroad. Compelling evidence indicates that one reinforce the other (learning-by-exporting). See, for example, Clerides et al., (1998) and Bernard and Bradford Jensen, 1999.

Table 2: Technology Adoption and Exporting Propensity by Domestic Firms (2010 or latest available)

(Share of firms engaged in total domestic firms)

	International Quality Certification	International Technology Licensing	Exporting (directly or indirectly)
Peru	13	6	13.8
Chile	20	9.2	12.4
Colombia	14.9	6.9	24.6
Argentina	16.5	11.3	18.3
Uruguay	8.2	3.8	6.4
Mexico	22	10	7.2
Brazil	10.2	7.4	n.d.
LAC average	14	14	n.d.
World average	11	13	n.d.
China	53.05	16.3	20.6
Malaysia	42.0	n.d.	49.7

Source: World Bank Enterprise Survey –Manufacturing Industry.

This delay in technology adoption is a missed opportunity to improve productivity in Peruvian companies. Technology transfer, generally defined as the process of acquiring, absorbing, and learning from foreign technology, is a fundamental prerequisite for innovation.[9] Successful catch-up has historically been associated with the adoption of existing technologies and techniques in established industries and the diffusion of global technologies, both hard technologies embedded in equipment machinery and soft technologies, such as managerial skills and methods. The experience of South East Asian countries has shown that firms can accelerate productivity growth relatively quickly by adopting global production techniques such as quality management systems and production standards, such as lean manufacturing, OEM standards, and other firm upgrading activities. This type of technology acquisition played a major role in the integration of South East Asian firms into global value chains (Fagerberg, Srholec, and Verspagen, 2010; OECD, 2007).

Under-investment in technology, research, and innovation has resulted in lower innovation performance for Peru compared to its peers across all indicators of science, technology, and creativity outputs. Table 3 provides a cross-country comparison for several indicators of STI performance. Accordingly, the number of scientific publications and patent production adjusted per GDP ranks the lowest within the comparison group. In absolute terms, Peru publishes about 31 indexed papers per year per million inhabitants, compared to 878 in Brazil and 709 in Argentina. The

[9] This learning process entails three different knowledge activities typically referred to as acquisition, assimilation, and improvement (Fagerberg and Srholec, 2008; Kim, 1993). According to many countries' experience, firms develop technological learning by acquiring and using imported machinery and equipment and acquisition of disembodied technology in arm's length contracting and know-how licensing, by reverse-engineering technologies and imitation (products and equipment), and by adapting foreign technologies to local market contexts.

quality of research in Peru is also lower than that of its peers in the region, as reflected in the H-index of publications (citation impact).[10]

Table 3: Science, Technology, and Innovation Outputs

	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Domestic resident patent appl. /tr. PPP $GDP[a]	1	2.1	1.1	0.4	0.7	0.2
PCT resident patent application/tr PPP $ GDP[a]	n/a	0.3	0.4	0.1	0.1	0
S&T articles/bn PPP $GDP[b]	10.3	14.9	17.1	6.1	5.9	2.1
Citable documents H index[c]	222	305	194	133	232	109
High and medium high tech manufactures (%)[e]	n/a	39.6	21.7	22.1	40.3	10
Royalty & License fees receipts, percent of total trade[f]	0.2	0.2	0.1	0.1	n/a	0
High-tech exports less re-exports (%)[g]	2.2	3.3	0.6	0.9	14.7	0.4
Communications, computer & info. services exports (% trade) [h]	2.3	0.3	0.4	0.5	0.1	0.3
Domestic resident trademark app./bn. PPP$ GDP[i]	83.2	51.7	88.9	37.4	42.3	56
ICTs & Business model creation[j]	45.7	61.3	67	59.2	59.8	55.8

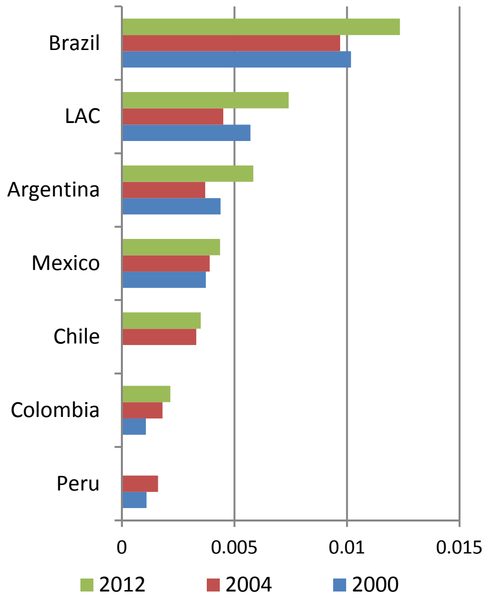
Sources: Global Innovation Index (WIPO) 2014 - which builds on several international databases.11

From the list of indicators reported in Table 3, there are only two indicators where Peru is not the worst performing: the number of resident trademark applications (per billion PPP GDP) –which is a broader indicator of innovation (firm brands referring to new economic activity: products, services, or new firm insignia); and ICT & business model creation. In the latter, Peru ranks 55th out of 143 countries, slightly better than Chile, Colombia, and Brazil, but worse than Argentina.

[10] These data come from the World Economic Forum and refer to a Likert-scale question on perceptions. Average answer to the question: In your country, to what extent do ICTs enable new business models? [1 = not at all; 7 = to a great extent] (WEF, 2013).

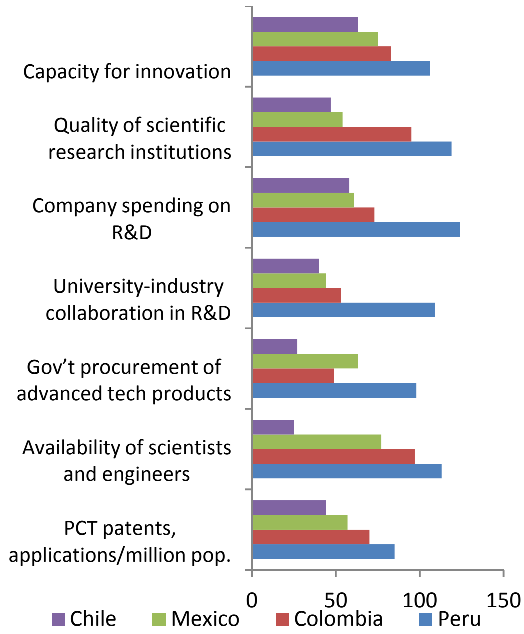
[11] *a*: World Intellectual Property Organization, WIPO Statistics Database and International Monetary Fund World Economic Outlook 2013 (PPP$ GDP) (2006–12); *b*:Thomson Reuters, Web of Science, SCI and SSCI; International Monetary Fund World Economic Outlook 2013 (PPP$ GDP); *c*: SCImago. (2007) SJR — SCImago Journal & Country Rank; d: International Labour Organization, Key Indicators of the Labour Market (KILM) database, Table 17b Labour productivity, special tabulations; *e*: United Nations Industrial Development Organization, Industrial Statistics Database INDSTAT4 2012; OECD, 'ISIC Rev. 3 Tech. Intensity Def. '(2004–10) ; *f:* World Trade Organization, Trade in Commercial Services database, based on the International Monetary Fund Balance of Payments database (2007–12);g: United Nations, COMTRADE database; e: Eurostat 'High-technology' aggregations based on SITC Rev. 4, April 2009 (2007–12); h: World Trade Organization, Trade in Commercial Services database, based on the International Monetary Fund Balance of Payments database (2007–12); and j: World Economic Forum, Executive Opinion Survey 2013–2014. International Monetary Fund.

Figure 4: R&D as a Percentage of GDP



Source: RICyT and UNESCO.

Figure 5: Innovation Capacity - Global Competitiveness Index



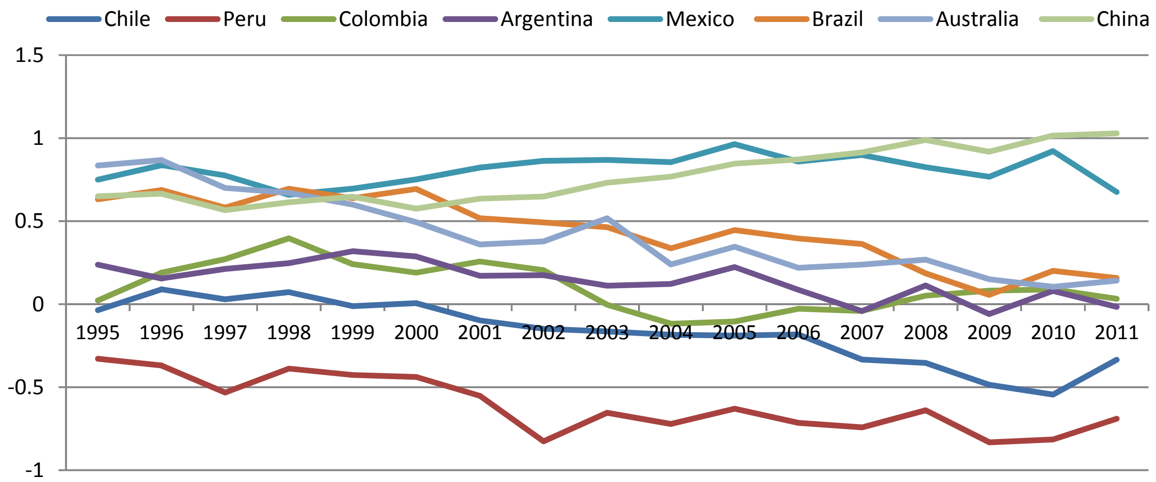
Source: Global Competitiveness Index (WEF)

Other international rankings confirm this weak innovation performance. In the GCI, Peru ranks behind its peers in every indicator of the innovation pillar, far behind the 100th place (in a list of 140 countries), including firm spending on R&D, number of patent applications, and quality of scientific research institutions (Figure 5). According to this methodology, Peru has not improved in recent years, and has actually fallen farther behind. Between 2010 and 2013, Peru fell from the 110th place to the 122th in a review of 148 countries. In the recently published GCI 2014-2015, innovation appeared as the least competitive pillar (within the 12 pillars of the GCI) with a score of 2.8 out of 6, whereas the in pillars of macroeconomic environment, health and primary education, goods market-efficiency, and financial development, it ranked the highest. In contrast, in the whole innovation pillar, Chile scored 3.5, 6 being the best, Uruguay, 3.2, Argentina, 3.0, and Brazil and Mexico, 3.3.

The export basket of the Peruvian economy also indicates difficulties in moving toward higher levels of sophistication. Only 0.4 percent of exports are considered high-tech compared to 2.2 percent in Argentina, 3.3 percent in Brazil, 0.9 percent in Colombia, and 6 percent in Chile. Three products represented about 50 percent of total exports. In 2013, gold-content and gold exports represented 18 percent and 19 percent of total exports, followed by petroleum, oils, refined (7 percent) and refined copper and copper alloys (5 percent).

According to new metrics (Hausmann *et al.*, 2011), the complexity of an economy indicates the multiplicity of knowledge competencies embedded in it, which can be combined differently to create new products and technologies. Therefore, competitive countries are those that show high diversification and high levels of economic complexity in their export basket. According to this methodology, Peru ranks at the bottom of countries reported in Figure 6 in the Economic Complexity Index (ECI) over the period 1995-2011. The level of complexity of the Peruvian export basked deteriorated over the period from -0.32 in 1995 to -0.68 in 2011, with slight improvements in recent years. Chile, Argentina, Mexico, and Brazil showed a decreasing trend in the ECI as well, but started reversing it. China increased in the ECI from 0.65 to 1.02 over this same period, and Colombia reversed its backward trend in 2004, reporting positive levels from 2008 onward.

Figure 6: Economic Complexity Index



Source: Observatory of Economic Complexity (MIT).

3. The National Innovation System –General Diagnosis

A country's innovative potential goes beyond the existence of a set of scientific entities, a research budget, and a national science, technology, and innovation policy program. This potential depends on the degree of development of various subsystems, such as political, economic, scientific, productive, and financial, and their capacity to interconnect and interrelate, producing, distributing and utilising technological and scientific knowledge, creating synergies, promoting competition, and establishing a sound macroeconomic, legal, and institutional framework which provides incentives, resources, and support for innovation activities (Freeman, 1987; Lundvall, 1992; Metcalfe, 1995; Nelson and Rosenberg, 1993).

The literature recognises that innovation is not a simple linear process that flows smoothly from research to application; rather, it is a collective process that involves interactive learning among researchers, firms, users, and others and requires multiple inputs, such as research, training, production facilities, and marketing. On this basis, a NIS is defined as the set of economic agents, institutions, and practices that perform and participate in relevant ways in the process of innovation. Actors in the NIS, including firms, universities, public agencies, governments, financial systems, and markets, contribute individually and jointly to the generation of knowledge, its diffusion, its use and exploitation, its adaptation, and its incorporation into production systems and into society (Freeman, 1987; Lundvall, 1992; Metcalfe, 1995; Nelson and Rosenberg, 1993). The effectiveness of the system depends on individual development trajectories and the accumulation of knowledge and skills available to the many participants in the system.

From the government side, public policy plays an important role in addressing market and coordination failures inhibiting innovation activities. Generally, the government has an important role in creating public and private institutional mechanisms that promote the generation, acquisition, dissemination, and application of knowledge and technology into the economy. The government can help facilitate capacity development of the system and its actors by: (i) providing incentives to innovate through the provision of public goods and infrastructure, such as publicly funded infrastructure for technology transfer, quality systems, and science; (ii) helping to reduce economic risks related to innovation activities and to information asymmetries surrounding investment in knowledge and innovation through co-financing and facilitating access to finance; and (iii) articulating a national strategy and vision for innovation and supporting the coordination needs for innovation in industries and sectors through the promotion of networks, markets, and innovation agendas.

In Peru, the NIS is still in an embryonic stage. As discussed by Kuramoto (2014), the elements are there but the capacity of actors to fully undertake innovation activities in formal ways remains limited, and the system as a whole is weakly articulated. We will next discuss key issues that hinder innovation in the private sector and factors that inhibit public research to impact industrial innovation. We also discuss the role of Government and the current policy landscape for innovation in Peru and benchmark against other LAC countries.

3.1 The Private Sector and Structural Obstacles to Invest in Innovation

The Peruvian business sector is fundamentally composed of microenterprises: over 90 percent of all businesses are microenterprises, of which only around 2 percent, concentrated in a few sectors, carry out innovation activities. Investment in innovation relative to firm sales is low compared to firms in other LAC countries (Figure 4), and very few firms engage in technology transfer and upgrading activities, such as the use of standards and quality certifications. Only 26 percent of manufacturing companies invests in R&D. The most important innovation activities undertaken by firms are acquisition of capital equipment (79 percent of firms), training (49 percent); and technology transfer (15 percent).

According to the innovation survey for manufacturing industries, on average most investment in innovation is financed with the firm’s own resources (59.2 percent of the investment). Private banks are the second most frequent source of financing, covering 37.9 percent of the investment, followed by other companies, with 2.1 percent, other sources, at 0.6 percent, and public support programs, which play a minor role, financing only 0.2 percent of innovation expenditure (National Innovation Survey, 2012).

The 2012 National Innovation Survey revealed that the obstacles to innovate encountered by Peruvian companies are diverse. The most important constraints are (i) the high costs of innovation (47 percent of non-innovating firms and 32 percent of innovating firms ranked this factor as very important); (ii) the lack of qualified personnel (41 percent of innovators and 33 percent of innovating firms ranked this factor as important); (iii) the lack of external sources of financing, followed by other disincentives like such as ease of imitation or market share . Thirty-two percent of non-innovating and 23 percent of innovating firms stated that markets are dominated by established companies, and therefore firms find it difficult to compete through innovation. For companies that innovated in the previous three years, the lack of qualified personnel was the most significant barrier to innovation, followed by the high cost of such activity.

Generally, surveys have found that a lack of qualified labour is a major constraint to business development. The Enterprise Survey reports that Peruvian firms' major concerns regarding the business environment are: (i) the practices of the informal sector, which is large and hinders growth opportunities; (ii) an inadequately trained work force; and (iii) crime, theft, and unrest, which make investment in production uncertain. According to several diagnostics (Yamada, 2008), higher education at the technical and university levels present deficiencies with regard to the pertinence and suitability of industry demands for qualified skills and the quality of programs and training. The number of private educational institutions has expanded substantially. Control of quality standards and accreditation has not received adequate oversight by federal agencies.

The impact of public research on private innovation is limited, given the weak linkages between industry and science and the lack of collaboration in innovation between the public and private sectors. Peru ranks 109th out of 148 countries in terms of university-industry collaboration, below all other countries considered (Global Competitiveness Report, 2013-2014). The Annual Economic Survey revealed that that fewer than 3 percent of the companies surveyed conducted collaborative activities with research institutions or universities for purposes of innovation or technological improvement related to new product development. This share is higher for large companies, but it is still fewer than 4 percent of companies. This figure contrasts dramatically with the propensity rates for collaboration in innovation in OECD countries. In Japan, Korea, and Germany, more than 25 percent of firms collaborate with other firms or public institutions for purposes of innovation. According to the Global Competitiveness Index 2013-2014, Chile ranks 40th, while Colombia ranks 54th.

The lack of a cooperative culture in Peru is a major barrier to its advancement in both innovation and productivity, given that technologies have become more complex and new products and services demand an increasing range of innovation competencies, which are often dispersed across different firms. Collaboration in innovation can have important benefits for firms. Cooperation with other firms, particularly with clients and suppliers, has frequently been related to increased innovation performance and productivity gains (Belderbos *et al.,* 2004; Cassiman and Veugelers, 2002).

3.2 The Public Sector: Universities and Research and Technology Institutions

An important handicap of the national innovation system is the current situation for public research institutions and universities engaged in research and technological activities. The public R&D and technology systems in Peru have been under-funded, fragmented (with weak interactions across institutions), and facing regulatory constraints to their expansion for several decades. Weak governance and lack of strategy development have also contributed to the limited role of these institutions in the development of R&D and innovation in Peru. Only a few public technology institutes and universities are actively engaged in R&D and technology transfer.

On the government side, there are 13 technology institutions (institutos públicos de investigación, or IPIs) attached to sectoral ministries (Ministries of Agriculture, Ministry of Mining, Ministry of Fishing, Energy, and Health) and mandated to undertake applied R&D and technology transfer to address sectoral demands. The majority, however, serve as information and data providers supporting regulatory agencies and ministries. Only a few conduct formal R&D activities.

Public institutions confront a wide array of difficulties in undertaking research and technology transfer with industry, including: (i) a lack of institutional or base funding to support research and innovation; (ii) lack of recognition in careers and evaluation performance of achievements in research and technology transfer; (iii) an aging population of researchers, older than the average for public institutions; (iv) administrative restrictions on hiring of new personnel and renewal of contracts; (vi) weak collaborative linkages across institutions; and (vii) weak internationalisation and linkages with global networks of R&D (CONCYTEC, 2014). Because of the lack of personnel due to limitations on hiring new professors and researchers, and the lack of well-defined responsibilities in the mission of institutions, faculty members devote limited time to R&D activities—two hours per teaching hour.

According to an assessment conducted by Finnish experts on the capacity and needs of IPIs (ADVANSIS and Finnish Innovation and Technology Group, 2012), these institutions suffer from stagnant institutional development and they face important financial challenges. Public financing has fallen over the last decade, while IPIs continue to rely on it for most of their operations. Most IPIs have not developed new funding streams, and they have weak interactions with industry. Another concern is the lack of strategic planning and limited coordination with their own ministries. New personnel have not been hired, which constrains IPIs' capacity to undertake formal R&D. The lack of employment opportunities for researchers at both entry and experienced levels, together with low salaries and a lack of competitive incentives represent important constraining factors to the development research and technological capabilities. This situation also prevails in universities.

In addition, the research system lacks a performance assessment system, and monitoring of activities is sporadic. This hinders assessment of capacity. Furthermore, the lack of a more homogeneous normative framework regarding ownership rights and commercialisation of publicly funded research results (rules on intellectual property rights creation and licensing) further handicaps the emergence of an innovation culture in public research organisations.

The university system also offers few opportunities for the development of innovation and technology transfer. Peru has about 100 public and private universities. Less than 15 are formally engaged in research activities. Publication is highly concentrated in three institutions as well as the productivity per researcher. Only one university reports having 2.8 publications per researcher in indexed journals between 2007 and 2011 (CONCyTEC), while in universities with the highest number of researchers, scientific production was below 0.5. As a result, productivity per researcher is highly skewed. Less than three universities publish almost 90 percent of all research. Among the public universities that conduct the most research are the Universidad Nacional de Ingeniería and the Universidad Agraria la Molina.

In terms of infrastructure for R&D and education in S&T fields, according to the CENAU Survey (2010) of science and engineering post-graduate students (CNTEC), 38.3 percent believed that laboratory conditions were normal and 10 percent believed they were bad. Perceptions about the quality of the university labs differed between private and public universities. The weak role of universities as centres and promoters of innovation is due not only to the lack of resources but also to the lack of external linkages. Universities are weakly connected to the rest of the innovation system–government agencies, ITIs, vocational schools, the private sector, and civic associations.

The sustained economic growth of the past decade has boosted demand for university degrees and the creation of some public universities, technology institutes, and private colleges. However, most of the expansion of university studies was in private universities, which enjoyed total legal, administrative, and financial independence in the absence of a national accreditation system to guarantee the quality of the study programs.

3.3 The Role of Government

(i) The Approach and the Funding

There are no recent internationally comparable statistics (e.g., UNESCO and OECD standards) available today regarding Peru's public expenditures on STI or R&D investment that would enable comparisons between Peru and other countries with regard to knowledge and technology investment relative to GDP. However, public budget data provide a clear message about the level of public expenditure related to STI financing (Table 4).

Accordingly, Peru's public efforts to promote STI, adjusted by size of the economy, remain extremely low compared to other LAC countries such as Chile, Colombia, and Mexico, which have consolidated data available. The National Council for Science, Technology, and Innovation (CONCYTEC) is one of the main public funding agencies for science and technology. The total budget for S&T executed by CONCYTEC in 2013 was US$17.4 million, while Colombia's budget for research (COLCIENCIAS) amounted to US$210 million in 2012. In 2013 alone, Chile spent US$546 million on S&T (CONICyT). In 2013, Mexico's executed budget for STI relative to GDP was 20 times larger than Peru's. Chile and Colombia's budgets were 10 times and 6 times larger than the total public budget executed for STI in Peru—considering the most important programs combined including budgets for CONCYTEC, the Innovation, Science and Technology Fund (Fondo para la Innovación, Ciencia y Tecnología, or FINCyT), created in 2007, and the Competitiveness Research and Development Fund (Fondo de Investigación y Desarrollo para la Competitividad, or FIDECOM) created by the Ministry of Economy and Finance (MEF) in 2006.

In parallel, the Canon Act (Ley del Canon), approved and launched in the 2000s, defined the use of royalties derived from the Canon to be shared with regional governments. Thus, it was legally defined that regions participated in the total revenue obtained by the government in the economic exploitation of natural resources. In 2003, the Act was amended to allocate part of the resources transferred to regional governments to finance investment projects intended to build research capacities at regional public universities.[12] Financing through the Canon Act is fairly substantial. However, a segment of its resources is untouchable due to rigid regulations restricting its use, as well as the universities' inability to absorb the totality.

The level of public investment in S&T was previously among the lowest in the whole Latin America and Caribbean region in early 2000s, according to the Science and Technology Indicators (Red de Indicadores de Ciencia y Tecnología, or RICYT). According to this source, in 2004 Peru's total expenditure for S&T was 0.15 percent of GDP, whereas the average for LAC countries was 0.53 percent. In spite of recent efforts to increase this investment, public allocation relative to GDP remains low compared to peer countries such as Chile and Colombia, and other countries in LAC. In 2011, Argentina's S&T expenditure reached 0.65 percent of GDP, while Brazil invested 1.21 percent, Colombia 0.18 percent, and Mexico 0.46 percent. On average, LAC countries invested 0.78 percent of GDP in S&T. Peru's gross expenditure in R&D relative to GDP in 2004 was 0.14 percent compared to 0.9 percent in Brazil, 0.65 percent in Chile, and 0.43 in Mexico. In 2004, the average R&D intensity in the LAC region was 0.53 percent.

For a long time, innovation policy was largely missing in Peru. Today, it remains underdeveloped. Before the creation of the National Fund for Science and Technology and Innovation (FINCyT-I), government support for research and innovation was quite limited in scale. Since the mid-2000s, several policy programs for research and innovation have been created. The FINCyT is currently under the umbrella of the Ministry of Production (PRODUCE). FIDEICOM and FOMITEC have been in operation since 2012 and are managed by PRODUCE through FINCyT. These three funds are competitive funding programs that support firm innovation and technology transfer.

In addition to a lack of funding for science, technology transfer, and firm innovation, Peru's national innovation system consisted of a purely supply-driven model, with little attention paid to innovation development by the private sector or demand-side policies. In the early 2000s, new public initiatives began targeting firm innovation, namely through the creation of extension centres (CITEs) led by the Ministry of Production (PRODUCE) and new financial support to firm innovation. The National Fund for Science, Technology and Innovation (FINCyT) was created in 2007 with a budget of US$36 million for 2007-2010–and is now in phase 2 (FINCyT-2) with three times the former budget. Additional competitive funds followed: the R&D Fund for Competitiveness (FIDECOM) and the Framework Fund for Innovation, Science, and Technology (FOMITEC), which provided additional funding of US$114 million and US$63 million, respectively, for 2013-2014.[13]

The Ministry of Agriculture has an important innovation program. Created in early 2000s, the INCAGRO program seeks to contribute to the development of a modern innovation system in the agriculture sector. It is demand-driven and led by the private sector to increase competitiveness by

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[12] A 2005 amendment specified that this investment should be devoted to spending on infrastructure and facilities and could not be used to pay fees or reimbursements.

[13] FIDEICOM supports innovation efforts of both individual SMEs and groups of SMEs in innovation and productive processes, as well as actions to transform technological and scientific research into new products or services. FOMITEC has mainly focused on the promotion of R&D and technological innovation in firms.

generating and adopting sustainable and environmentally safe technologies.[14] In the first two phases, 2001-2004 and 2005-2009, INCAGRO financed 610 projects, representing a commitment of over US$44 million.

Table 4: Comparison of Budget Execution by National Councils of Science and Technology, 2013 *(in millions of US$ and percent of GDP)*

		USD	percent GDP
Mexico	Total CONACYT budget (executed 2011)	1,060.1	0.091 percent
	Innovation Budget (within CONACYT)	185.8	0.016 percent
Chile	CONICYT Budget (budget 2013)	546.0	0.197 percent
	Innovation budget -Managed by InnovaChile	155.6	0.056 percent
	Other S&T expenditures (other agencies)	335.5	0.121 percent
Colombia	COLCIENCIAS Budget (executed 2012)	210.6	0.057 percent
	Innovation Budget (private sector) -Managed by Inpulsa	40.0	0.011 percent
Peru	CONCYTEC Budget (2013- fully executed)	17.4	0.009 percent
	Research and Innovation Budget by FINCIT (Executed in 21013)	16.6	0.008 percent
	Other funds for research and innovation (FIDEICOM)	11.9	0.006 percent

Source: Informe de Rendición de Cuentas de la Administración Publica 2011 (Mexico); CONICYT Institucional Brochure 2013 (Chile), Informe de Gestión 2012 (Colombia). Note: Mexico's data are 2011 expenditures, Chile's are from its 2013 budget, and Colombia's are from its executed budget (95 percent of the allocated budget). For Mexico, the numbers do not reflect total S&T expenditures, as CONACYT represents only US$1 billion, although the total for the country is US$4.7 billion (see first table). Colombia: Informe de Gestión 2012. For Peru: Plan Operativo 2012.

Figure 7 summarises the state of development of supply-side policies—policies targeting the development of science, advanced human development in S&T, and public technological infrastructure—while Figure 2 presents the current state of policy development for firm innovation and linkage policies. From this picture, it is clear that Peru has fewer instruments in the three policy areas. Specifically, its innovation system lacks linkage mechanisms compared to those of leading LAC economies.

According to this policy review, Peru still lacks basic components of supply-policies, such as support programs for national post-graduate programs in S&T, complementary salary incentives to scientists at public research organisations, and diaspora networks in S&T, or formal collaborative mechanisms with Peruvian researchers located abroad. There are no incentives to encourage the young to study science and technology-related careers. The first efforts to create a critical mass of

[14] Based on competitive funds, two main mechanisms of INCAGRO have been the Agrarian Technology Fund, to develop an efficient market in agrarian services especially adaptation research and extension services; and the Strategic Services Development Funds, to strengthen institutional capacity of extension service providers and strategic investment.

research and researchers in priority fields and sectors started a few years ago with the Chairs program and continued in 2014 with the creation of the Centres of Excellence Program.

Figure 7 : Supply-Side Policies: Peru and LAC Countries

Instrument/Country	ARG	BRA	CHL	COL	CRI	DOM	GTM	MEX	PAN	PER	PRY	SLV	URY
S&T Funds	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green		Green
Support to centres of excellence	Green	Green	Green	Green				Green		Yellow			Green
Scholarships for undergraduate, graduate and postgraduates in S&T	Green	Green	Green	Green	Green			Green	Green	Yellow			Green
Support programs for national postgraduates in S&T	Green	Green	Green	Green	Green			Green	Green		Green		Green
Salary incentives to research in S&T	Green							Green	Green				Green
Affiliation with national researchers abroad	Green		Green					Green	Green				Green

Source: Updated from "Políticas e Instrumentos en Ciencia, Tecnología e Innovación en América Latina y el Caribe 2009: IDB, REDES and RICYT."

In terms of demand-side policies, Peru has several innovation and competitiveness funds, and it has created public and private mechanisms to facilitate technology transfer via technology extension centres, although they have limited capacity and impact. The government has also recently introduced tax deductions for R&D investment and equipment acquisition. However, policy support for firm innovation still reaches less than 1 percent of companies (Figure 9), which is among the lowest coverage in LAC countries for which data are available. In Brazil and Chile, although still in development, innovation policy instruments are being used by more firms: 8 and 6 percent of companies, respectively.

Most of the public support being used by firms is largely concentrated in personnel training. According to the National Innovation Survey, in the manufacturing industry about 64 percent of firms (1325 firms out of 2153 companies in the sample) applied for some training program sponsored by public agencies, and 60 percent of them received support. Training appears to be the main productivity program currently being used by Peruvian companies; it is followed by "other programs" and programs to support technical assistance and adoption of technology and managerial skills, with about 10 and 7 percent of companies applying for this support. Among firms that have introduced a technological or non-technological innovation, 76 percent used public programs for personnel training with CITES, SENATI, or others. This is by far the most frequently requested program by firms (Figure 10).

Figure 8: Demand-Side and Strategy-Articulation Policies—Peru and LAC countries

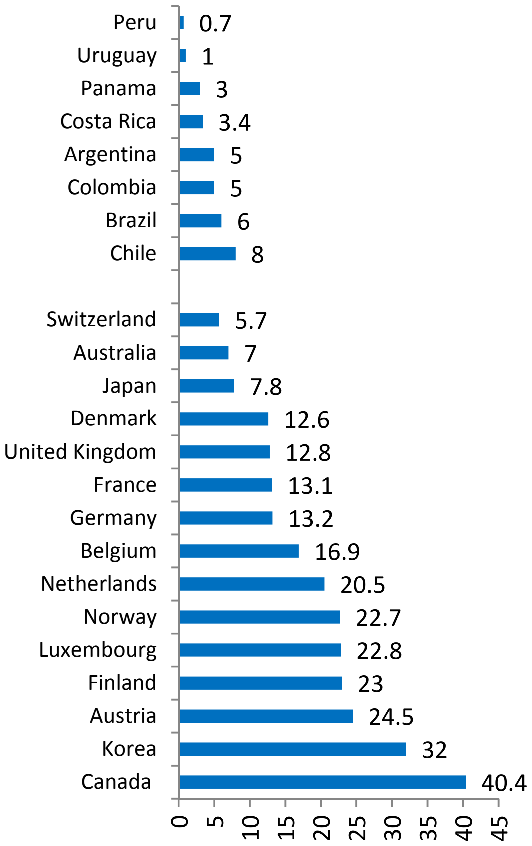
Instrument/Country	ARG	BRA	CHL	COL	CRI	DOM	GTM	MEX	PAN	PER	PRY	SLV	URY
Demand instruments													
Technology and competitiveness funds													
Venture capital and other financial funding for firms													
Fiscal incentives for R&D													
Promotion of technology transfer (extension technology services and others)													
Strategy and articulation instruments													
Sectoral funds													
Priority area programs													
Innovation clusters, promotion of conglomerates, business incubators, etc.													
Mechanisms for enhancing regional innovation systems													
Coordination mechanisms between actors in NIS													

Source: Updated from "Políticas e Instrumentos en Ciencia, Tecnología e Innovación en América Latina y el Caribe 2009: IDB, REDES and RICYT".

Although not explicitly presented in these tables (e.g. Sectoral Funds and Priority Programs), vertical policies are also underdeveloped in Peru. Most sector-oriented initiatives to date have focused on the promotion of crosscutting technologies or sectors of high social relevance such as water or the environment. The Ministry of Trade and Tourism's SIERRA Exportadora program has recently adopted this approach, focusing on innovation agendas for key sectors of the economy in the Sierra region. These programs link clusters or value chains, finance road mapping, network formation and commercialisation platforms, support quality and product development and modernisation of production systems, and others. Weak linkages, however, prevail between this program and other horizontal innovation funding programs and respective agencies.

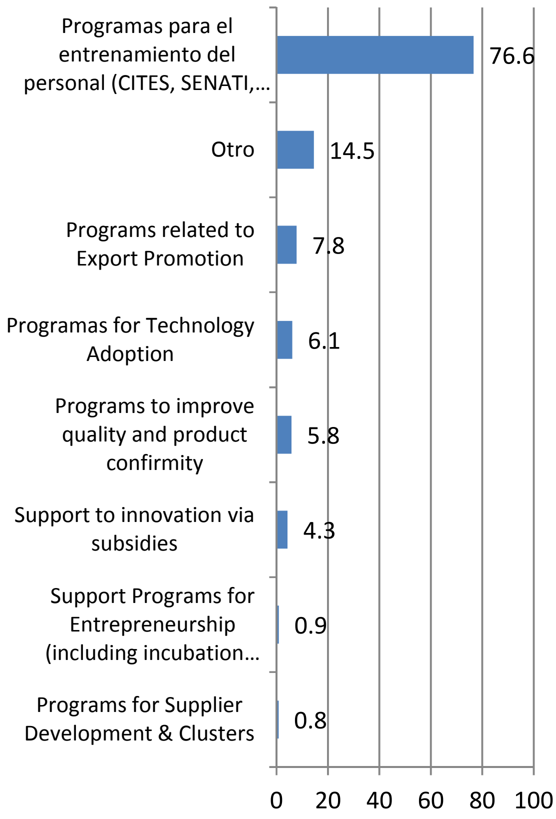
Mechanisms for policy coordination, such Inter-Ministerial Councils for Innovation, across agencies and between actors of the innovation system, such as technology platforms linking business sectors with public research and technology organisations, are still absent in Peru. There is also less progress in the adoption of institutional mechanisms or policy instruments to enhance regional innovation systems. Only Brazil, Chile, and Mexico have formally undertaken actions in this domain in LAC (Figure 2). The creation of Regional Councils for Science, Technology, and Innovation, supported and coordinated by CONCyTEC, are a first important step in this direction.

Figure 9: Percent of Firms that Received Public Support to Finance Innovation



Source: National Innovation Surveys and Enterprise Survey (Peru). Data refer to Manufacturing Industries.

Figure 10: Types of Government Support Received by Innovators (firms that innovated)



Source: National Innovation Survey (2012).

(ii) Governance and Policymaking

Peru has taken steps to develop a national vision and policy agenda for STI. The National Strategic Plan for Science, Technology and Innovation for Competitiveness and Human Development (*Plan Nacional Estratégico de Ciencia, Tecnología e Innovación para la Competitividad y el Desarrollo*

Humano) (PNCTI 2006-2021) was the first such plan. The Plan was conceived with a long-term horizon and was developed with the participation of several actors from the innovation system to provide a more demand-oriented approach to STI policy.[15] The initiative, however, remained mainly a long list of needs with weak implementation due to the lack of a concrete action plan and budget allocation.

The two main public funding agencies for STI policies are the Ministry of Production and the National Council of Science, Technology and Innovation (CONCyTEC). Other government actors include the Ministry of Economy and Finance (MEF); the Ministry of Education, the Presidency of the Council of Ministries (PCM), the Development Finance Corporation (COFIDE), and the ministries and their respective sector-oriented research and technology organisations and funding programs: Agriculture (INIA, SENASA, and INCAGRO); Environment (IIP, IGP, and SENMHI), Defence (IGN and CONIDA), Energy and Mining (INGEMMET and IPEN), and Health (INS).

CONCyTEC is the main agency in charge of funding for research and advanced human capital (post-graduate in S&T). It is a decentralised public body created in the early 1970s. It was conceived as the main agency promoting the development of science, apart from the sector-oriented research organisations created under the umbrella of the ministries that existed at that time—Energy, Mining, Agriculture, and others. In 2004, a national law for STI was enacted (Law No. 28303 – Framework Act on Science, Technology, and Technological Innovation of 2004) that provided the system with governing rules and definitions. This law made CONCyTEC the coordinating agency of the national innovation system (SINACyT) and made it responsible for developing, promoting, and coordinating STI policy.[16] The law defined the State's role in STI activities, including generation, promotion, transfer, and diffusion, and recognised STI as a public good in the national interest.

CONCyTEC's main function, however, has been the formation and funding of advanced human capital (MSCs and PhDs) and scientific research. CONCyTEC has suffered from several weaknesses that have limited its role in promoting and steering of innovation policy and in the innovation system as contemplated by the 2004 Law. For a long time, this institution remained under-funded, and its lack of political power undermined its capacity to lead and coordinate STI policy across stakeholders and agencies. It still lacks mechanisms to address and channel innovation demands by the private sector. Its proposals for public investment require authorisation by the Presidency of the Council of Ministers (PCM), which oversees CONCyTEC.

The main implementing agencies for STI policy, CONCyTEC and the Ministry of Production (PRODUCE), both design and implement innovation policies, which are presumably complementary. The INCAGRO program is another major implementing arm. Previously attached to the Ministry of Agriculture, it has now become an independent innovation program. PRODUCE targets firm innovation more broadly, while CONCyTEC mainly focuses on science and human capital at

[15] The Plan emphasises and seeks institutionalization of the national innovation system and its mobilization and prioritises human capital development and its quality.

[16] The law also stated the definition of the national system of science, technology and innovation (SINACyT) and defined its basic components. The Law also set forth out the establishment of the National Advisory Council for Science, Technology and Innovation (CONID), and created the National Fund for Science and Technology (FONDECyT) under the budget execution arm of CONCyTEC, among other things. For more information on the institutional and legislative framework see UNESCO (2011).

research organisations.[17] Both institutions have published national strategies for STI and productivity. CONCyTEC recently published “Crear para Crecer” –which aims to be the national strategy for STI. More than an action plan, the document is an updated diagnostic of the national innovation system and identifies key challenges. It proposes a series of policy actions to be deployed, particularly addressing the fundamentals for strengthening science and research capabilities, and innovation in Peru. PRODUCE developed the National Plan for Diversificación of Production (*Plan Nacional para la Diversificación Productiva*). Compared to previous strategies in these areas, these policy agendas have advanced in their planning and design and provided target measures, budget requirements, and a description of concrete mechanisms to achieve their objectives. The horizons for implementation however remain very short term—three years (2014-2016).

There are weak interactions between agencies and programs. Mechanisms for policy coordination and collaboration, such as bilateral participation in evaluations and committees and follow-up on projects and firms, are lacking. Generally, policy coordination is a weakness for the articulation of innovation policies and Peru’s innovation system. (OECD, 2011; UNCTAD, 2011). As the OECD study (2009) stresses, major handicaps in governance of Peru’s innovation system are: (i) confusion between policy design and program funding and management, both of which still overlap in several agencies, creating conflicts of interests regarding the use of resources; (ii) excessively broad missions of executing agencies and funds; and (iii) prevailing institutional rigidities and overwhelming legalistic frameworks that hinder the development and the effectiveness of policy instruments.[18]

Governance of national innovation systems in advanced countries like Finland, Germany, and Norway functions as a division of labour with a well-defined and limited number of executing arms, or agencies of excellence and a leading cross-sectorial council in charge of mainstreaming innovation policy. [19] In Peru, although advisory councils or committees have been created within the government to mainstream innovation policy (e.g. Innovation Council, National Competitiveness Council), these initiatives remain mostly governmental.[20]

The use of prospective studies in policy design and the adoption of monitoring and evaluation (M&E) in innovation policy and in productivity policies are also areas yet to be developed in governance. It has not been until recently that national plans have integrated specific targets to be reached and indicators for expected impacts and a definition of instruments to implement lines of actions. The current strategies, however, do not use prospective studies in policy design; the

[17] Created in 2014, the National Innovation Program for Competitiveness and Productivity (Innóvate Perú) is one of the main executing arms of the Plan Nacional para la Diversificación Productiva. The program integrates three previous funding schemes: (i) Proyecto de Innovación para la Competitividad (FINCyT 2); (ii) Fondo de Investigación y Desarrollo para la Competitividad (FIDECOM); and (iii) Fondo Marco para la Innovación, Ciencia y Tecnología (FOMITEC).

[18] The analysis of UNCTAD (2011) arrived to similar conclusions.

[19] Chile adopted this approach and created in 2005, by presidential decree, the National Innovation Council (Consejo Nacional de Innovación para el Desarrollo), a public-private organization with the mission of advising the president on the identification, definition, and execution of policies and actions to strengthen innovation and competitiveness in Chile.

[20] Peru has not developed bottom-up mechanisms or a more formal consultation approach (including industries and firms; and civic associations such as labor associations) to identify innovation demands in the private sector and mainstream policy priorities, which then need to be reflected in national strategies and plans.

corresponding budget allocation for each of the actions to be deployed and a formal monitoring and evaluation (M&E) framework have yet to be developed. In the past, policy design usually resulted in a wish list for knowledge areas that should be developed, but no operational plans were developed and no budget was assigned to implement the proposed S&T activities.[21]

Finally, Peru has one of the weakest statistics bases in the region on science, technology, and innovation investment. The last year that STI statistics were gathered was 2004 and data collection was discontinued. The lack of measurement hinders the monitoring of policies and international benchmarking as well as possibilities for policy learning and adjusting. Furthermore, Peru has not developed an M& E framework for innovation policies. FINCyT and CONCyTEC have begun efforts in this direction.

(iii) Technology Transfer and Supportive Infrastructure

To support technology transfer and innovation capacity in SMEs, the Ministry of Production created a network of technology extension centres (*Centros de Innovación Tecnológica Empresarial*, or CITEs) in the early 2000s.[22] Technological services offered include: technical assistance; certifications and conformity tests, pilot plant demonstrations; diffusion of technical and market information; studies and analysis of world trends; and training services. To date, 13 CITEs have been stood up, 10 of which have been purely private. As explained by Kuramoto (2014), the CITEs program filled a gap in Peruvian productivity and innovation policy. It is the only policy instrument that provides technical assistance and other technological services to industrial firms and productive chains.[23]

However, the program has several limitations. First, it has not been matched with complementary measures to enhance the firms' demands for technology services and upgrading. This issue is critical given that SMEs often do not engage in such activities because they do not know what they need and they are often unaware of the benefits. Second, many of the CITEs struggle to fund their operations, and limited public funding has been a major constraint. Not all CITES are fully operational. Only a few are well connected to industries. In addition, the CITEs are understaffed. They have only on average 13 employees per CITE, which is 4 percent of the average employment in public research institutions. This situation has limited the capacity for growth and updating of infrastructure, and for the expansion and quality of the services offered. As a result, although some of the CITEs have been successful in achieving their objectives, their impact remains limited, as they only reach a few firms.[24]

[21] Kuramoto (2014).
[22] Three CITEs were created between 1998 and 2000 as a result of an agreement signed by the former Ministry of Industry, Tourism and International Trade, the Export Promotion Office and the Government of Spain.
[23] CITEvid is a specialised institution in viticulture aimed at improving the quality, productivity, information, and innovation of the different links in the pisco and wine-making chain as well as support the domestic and international promotion of Pisco; CITE-ccal aimed at the technological upgrading of Peruvian leather and footwear production; CITEmadera aimed at improving innovation and quality in the wood and furniture industry).
[24] The need to increase capacity of the national extension system has been recently recognised in FINCyT-2, which has three matching grant schemes to incentivise supply and demand of extension services, including strengthening

Overall, Peru's public support for SMEs is lower than that of Chile, Argentina, Brazil, and Mexico (see Table 5), in both absolute and relative terms, as a share of GDP. In 2010, according to Andes *et al.* (2013), the Ministry of Production's annual budget was US$31.9 million (0.02 percent of GDP), whereas in Chile, public support for SMEs reached $56.20 through SERCOTEC (0.03 percent of GDP) only. CORFO's annual budget -which covers several areas, including innovation, SMEs finance and entrepreneurship- amounted to US1.9 billion in 2010, or 0.87 percent of GDP. Brazil and Mexico allocate the highest rates to SME support within this group of countries: 0.09 percent and 0.06 percent of GDP, respectively.

Table 5: SME Programs: Budgets in Selected Countries (2010)

	Main Institution	Budget	As percent of GDP
Argentina	SEPyME	$88.1 M	0.02
	INTI	$78.2 M	0.02
Brazil	SEBRAE	$1.6 B	0.08
	SIBRATEC	$159.8 M	0.01
Chile	SERCOTEC	$56.20	0.03
	CORFO	$1.89 B	0.87
Mexico	SPyME	$633.8 M	0.06
Peru	**PRODUCE**	**$31.9 M**	0.02
Costa Rica	DIGEPyME	$1.7 M	0.00

Source: Andes et al. (2013) and World Development Indicators (GDP 2010 in current USD).

UNCTAD (2011) emphasised three main weaknesses in the Peruvian national infrastructure for innovation: (i) embryonic infrastructure for incubators and accelerators and weak development of technology parks, (ii) insufficient equipment in public research laboratories, and (iii) deficient equipment related to the national quality system.

Generally, Peru's national quality infrastructure has yet to be established. This challenge has been recognised in several diagnostic studies (AENOR and IDB, 2010; UNCTAD, 2011). The 2010 assessment by AENOR[25] found that Peru's national quality system was underdeveloped and suffered from a weak interrelation among public and private national providers and the productive sectors. There is a shortage of accredited laboratories, and the national metrology system is insufficiently developed to respond to business demands (UNCTAD, 2011).

The national quality system (NQS) consists of several regulatory areas and services that are closely interrelated: standards and technical regulations, metrology, standardisation, testing services, certification, and accreditation.[26] Each of these components is critical to production and development of national and international trade and attracting FDI, especially in manufacturing. It is also

operational capacity of CITEs. The new Program for Productive Diversification for 2014-2018 considers this theme a priority area to develop in the next four years.

[25] Diagnóstico del Sistema Nacional de Calidad Peruano y Plan de Acción para su Fortalecimiento (2010) by Asociacion Española de Normalización y Certificación (AENOR) (2010) –Background Study commissioned by the Consejo Nacional de Competitividad –Proyecto Fortalecimiento Infraestructura de Calidad Perú.

[26] These activities and the institutional setup of organizations to support them and their interconnection together with regional/international institutions and practices is the mandate of the National Quality Infrastructure.

fundamental to consumer protection in that technical norms guarantee safety and quality of goods, products, and services in markets.

Consolidating the NQS, which implies developing an adequate regulatory and coordination framework and improving the capacity of providers and efficiency of services, is fundamental to enhancing innovation and the competitiveness of the Peruvian economy. Recently, the government took action to fill this gap. In July 2014, the Congress implemented a new law authorising the creation of a National System for Quality (Sistema Nacional para la Calidad, or SNC). This initiative is designed to carry out the new National Policy for Quality to strengthen consumer protection and increase the competitiveness of the Peruvian economy. With an injection of public funding, the national metrology system will be updated, and new governance entities for the coordination of standards and norms are now being created. [27] The activities of the SNC will be developed based on international norms, guidelines, and recommendations, with the aim of harmonising them in Peru and facilitating the trade of goods and services.

(iv) The Regulatory Framework: Competition, IPRs, and Doing Business

A major public actor in the promotion and protection of innovation is the National Institute for the Defense of Competition and Protection of Intellectual Property Rights (INDECOPI). Created in 1992 by decree No 25868, its functions are to promote the market and protect consumers' rights. It also promotes a culture of competition and innovation through the protection of intellectual property rights by applying trademarks and geographic denominations, copyrights, and plant breeders' rights to patents.[28]

In the policy area of competition, Peru has undertaken important reforms. According to the GCI, the intensity of domestic competition ranks high among Latin American countries. Peru has 65th place, above Brazil, Mexico, and Colombia, but behind Chile (34th) and Uruguay (46th). Among the weaknesses highlighted in the UNESCO assessment, Peru's competition policy framework could be improved, particularly regarding the treatment of mergers and acquisitions.

In addition to Competition Policy, INDECOPI was until recently also in charge of regulating quality system (standards and norms) and intellectual property rights (IPRs). The former has now been integrated into the Ministry of Production, and IPRs remain under the umbrella of INDECOPI. This accumulation of important institutional roles within a single entity has been pointed out by several international reviews (e.g. UNCTAD 2011) as a factor hindering the effectiveness of policies.

Intellectual property rights are another underdeveloped area in terms of promotion and capacity building, compared to competition and consumer protection policies. Institutional capacity of the IPR department remains weak, with few staff and limited technological capacity for the processing, registration, and promotion of IPRs. Efforts to promote the IPR system have been quite

[27] The system will be integrated by the National Quality Council (Consejo Nacional para la Calidad, or CONACAL), the the National Quality Institute (Instituto Nacional de Calidad, or INC), and technical committees and public and private entities participating in national quality infrastructure and services.

[28] INDECOPI has legal personality in domestic public law and therefore, it enjoys functional, technical, economic, budgetary, and administrative autonomy (UNESCO, 2011).

limited. The IPR system remains under-used by the private sector and the topic has lacked promotion and outreach programs, particularly for SMEs. SMEs are often unaware of the IPR system and its benefits, and they often need assistance in the preparation of IPR applications (trademarks, geographic designations, and patents, among other IPRs).

The legal framework for IPRs is mostly in line with international standards. Peru is a signatory of the main international agreements, including the Patent Cooperation Treaty (PCT). More progress on enforcement is needed. According to the Global Intellectual Property Center (GIPC 2015) report, Peru has a poor intellectual property environment compared to Colombia, Mexico, and Chile.[29] The Peruvian IPR system's main weaknesses are: the lack of a patent examination process; lack of effective pharmaceutical-related patent enforcement and resolution mechanisms; an outdated basic digital copyrights regime; failure to implement software legalisation; high rates of software piracy and counterfeiting; and an overall weak enforcement environment of IPRs.

Table 6: Doing Business Ranking of Peru 2014 and 2013

	DB 2014	DB 2013	Change
Business opening	63	60	-3
Building permits	117	97	-20
Electricity supply	79	78	-1
Property registration	22	19	-3
Ease of credit	28	24	-4
Investment protection	16	16	No change
Tax payment	73	76	3
Global trade	55	49	-6
Contract enforcement	105	108	3
Insolvency resolution	110	108	-2

Source: Doing Business (World Bank).

In terms of doing business performance, Peru ranked 42nd in 2014 -among the highest in LAC- although still behind the Asian Tigers, which ranked 6th. Peru's overall ranking improved 1 place to 42nd between 2013 and 2014, but some of its indicators were worse, particularly regarding construction permits. Peru still has several areas in which it could improve in the doing business environment. More than 20 percent of firms indicate that licensing and permits are a major constraint to business growth; this is almost three times the percent of firms in Chile. Business procedures/regulations are still more time consuming than for LAC peer countries, which indicates a significant need for improvement. The resolution process for insolvent firms remains inefficient, and it is expensive to obtain an electricity connection.[30]

[29] The 2015 Global Intellectual Property Center (GIPC) Index is a composite indicator that measures the national IPR environment based on the state of legal frameworks and their enforcement. The Index maps the IPRs environment of 30 economies, comprising nearly 80 percent of global GDP. Economies' GIPC Index scores are evaluated based on 30 indicators indicative of a robust IPR system.

[30] Over 14 percent of senior management's time is spent dealing with bureaucratic requirements, above the LAC average. Enforcing contracts is quite costly in Peru (35.7 percent of total claim value), above the LAC average and

Generally, the Global Competitiveness Index (WEF) 2013-2014 shows that Peru has been improving in several aspects of innovation and competition, particularly: it shows a strong macroeconomic performance (ranked 20th), and high levels of efficiency in goods markets (52th), financial system (40th), and labour markets (48th). Nevertheless, the areas that still need improvement include: strengthening the soundness of public institutions (124th); need for greater government efficiency (107th), fighting corruption (109th), and improved infrastructure (91th).

Enterprise surveys point to informality, lack of education, and crime, as the most common business environment constraints. 29 percent of companies consider informality as hindrance to business development and 13 percent declare that lack of qualified labour is an obstacle to business growth. Formal registration when starting a business is less common practice in Peru than the LAC countries' average, and two-thirds of firms find themselves competing with informal companies.

4. Conclusions and Policy Recommendations

Peru has delayed taking action to increase its national innovation capacity compared to its peer economies and other countries in the region. This review has shown that Peru's national innovation system is underdeveloped and that many of the fundamentals that the business sector needs to invest in innovation are still lacking. Overall, the national innovation system needs to be strengthened, better funded, and articulated through the addition of improved governance and formal interactive linkages, and a common strategic vision over the long-run. This requires strong political will and greater commitment by the different stakeholders to engage in innovation activities and to transform the productive system into a more efficient, sophisticated, and diversified economy.

The benchmarking exercise highlights two main characteristics: (i) Peru's investment in innovation—both adaptive innovation, based on technology adoption and technology transfer, and upfront innovation, based on R&D competencies—has not kept pace with its economic dynamism and level of development; (ii) the system performs well below its full potential given the lack of incentives to engage in innovation activities in either the public or private sectors. In spite of important legal developments and decrees that have been created over the years, recognising the importance of innovation for Peru's economic development, budget allocations to address these concerns have long been absent or small in the best cases.

The benchmarking exercise also showed that Peru lags behind peer economies in several indicators of innovation performance and in achievements related to science, technology, and innovation. In several areas of innovation activities, it ranks well below the LAC average. The system suffers from a lack of competencies on different fronts—from human capital and quality of education, to firm technology adoption and investment in R&D and lower innovation and economic performance of firms, that is, exporting and linking with foreign firms. In spite of new efforts, public initiatives have limited funding that is fragmented or split among three or four institutions with overlapping programs, and weak coordination among different pertinent policy agencies.

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about twice as expensive as in Brazil and Argentina. With regard to insolvency, recovery rates are less than half of those observed in Mexico and Colombia (and below the LAC average) but similar to Chile and Argentina (around 30 percent).

In a nutshell, the Peruvian innovation system has not kept pace with the economic dynamism attained over the last decade, and it will not respond to the major challenges of productive diversification and increased productivity if Peru fails to undertake system-changing measures to improve innovation capacity, funding, and governance.

General Recommendations

Public policy and government have a fundamental role in strengthening innovation capacity in Peru. Government action entails strengthening: (i) public investment in the provision of public goods, such human capital development, S&T and innovation centres and supporting the development of a national innovation infrastructure, such as a national technology transfer system and national quality system; (ii) financing of firms' innovation activities, through direct funding and subsidised finance, such as credit lines, and tax incentives; and (iii) governance of the national innovation system through improvements in the regulatory framework for business and market development and better governance of public sector organisations.

The renewed policy approach for innovation should tackle fundamental weaknesses of the innovation system and set the basis for its better articulation and coordination. Our general recommendations are:

- ***Strengthen public support for innovation in line with industry needs and the level of development achieved***. Public support for firm innovation should address the different ways for firms to acquire and develop knowledge, especially about technology transfer, and further emphasise public-private collaboration to address key bottlenecks and deficits in industries. It will be necessary to:

    - *Facilitate and support technology adoption of global technologies including equipment, methods, and managerial competencies and the process of technological learning and firm upgrading in SMEs.* The objective is to accelerate catching up and stimulate firms to engage in incremental innovation. This strategy will entail reinforcing the national technology transfer system and the creation of firm innovation centres, including technology extension centres.

    - *Support the strengthening of R&D investment with applied R&D focus in the public sector and the transfer of new innovative competencies to the business sector*. Strengthening national R&D capacity requires strengthening and modernising the public R&D system, that is, governance, infrastructure, funding, and facilitating industry-science collaboration to address sectoral needs for innovation. Investing in R&D is fundamental for middle-income countries to foster economic diversification, that is, create new industries and new value-added applications from traditional industries and develop long-run sustainable competitive advantages.[31]

[31] New economic competencies for the long run can only be achieved through experimentation and the search of new technological solutions based on technological innovation, which is R&D based. Further, R&D is fundamental to address environmental, health, energy, and water-related challenges and climate change.

- *R&D and technology diffusion policies are intertwined*: they are complementary, as the former eases the process of technology transfer and they reinforce each other. R&D activities in public organisations can support sector-level industrial innovation agendas and their diffusion via the national technology system. Examples of this approach are numerous, especially from the developed world. In Brazil, the most important example is EMBRAPA–a public research organisation engaged in R&D and technology extension that helps to transform agriculture productivity; and the Fraunhofer Institutes in Germany, which are engaged in R&D activities and technology diffusion programs that support technological change in manufacturing firms.

- ***Promote dynamic consistency in innovation and research policy***. New policy efforts should be sustained over time as investments in knowledge and innovation, particularly in R&D, given the path-dependent and cumulative nature of knowledge and the long time horizon needed for certain policies to materialise in new sustainable and competitive advantages. These include advanced human capital and science and R&D policies. Policy consistency over time and coherence across different policy actions targeting innovation are necessary to make a real impact on economic development and growth.

- ***Continue improving the business and regulatory framework in order to provide enhanced incentives (market and non-market) for firms to invest in innovation***. This includes improving market competition conditions, the regulatory context for business creation and exit, and the IPR system. The latter involves strengthening its enforcement and use by firms, especially SMEs to foster competitiveness and market impact.

- ***Strengthening framework conditions for innovation****:* Innovation in firms will not take off, in spite of increased policy support, if framework conditions such as qualified human capital and financing are not improved. This means that education and educational quality should be strengthened and better matched with industry demand for skills.

- ***The system also needs a long-term strategy and joint vision facilitated by consensus-building mechanisms.*** Federal and regional governments play a critical role in this process. The authorities could help define the roles of disparate agencies, improve coherence and coordination across agencies, and help build a shared vision among actors in the innovation system.

In the last few years, the government has taken steps to address these deficiencies and has started increasing public budget allocations to science, technology transfer, and innovation. There is a need for new policy instruments and a more systemic approach to innovation, along with a more effective use of public resources.[5] The following are some specific recommendations by policy area and for the issues we consider the most important for the development of national innovation capacity in Peru.

(i) Education and Skills for Innovation

- Establish quality control mechanisms and a more rigorous accreditation system for higher education.
- Consider funding support, such as scholarships, to promote technical education as well as S&T careers in tertiary education.
- Engage in a program to promote science and engineering careers and careers in ICT, design and architecture, and others facing strong demand.
- Include industry in the revision of education and training programs to ensure a better match between supply and demand for skills. In terms of technical skills, Peru needs to establish demand-driven training programs.[32]

(ii) Advanced Human Capital in S&T

In order to fill the gap in qualified human capital (S&T graduates and post-graduates), the government should consider both short and long-term policy actions. These include:

- With regard to advanced human capital, such as MSC's and PhD's in Science and Technology, current educational programs should be expanded and better integrated with post-graduate schools to ensure the training of new researchers through PhD programs. In deploying such efforts, public support should strengthen post-graduate and doctoral schools, and, if needed, create new ones for which there is a tangible economic and social demand.
- Regulations regarding employment at higher education institutions need to be revised and new positions created for young researchers. This applies to both universities and public research institutions. These actions should be undertaken to retain new skilled human capital and attract scientists from abroad.
- Generally, investment in advanced human capital formation will be wasted unless active measures are taken to ensure adequate retention. This should start with:
    - Opening new positions at research and technology institutions and universities and with repatriation programs and post-doctoral programs.
    - Salaries should be revisited and new revenue incentives provided, in addition to salaries and attached to performance as, for example, in the case of the National System of Researchers in Mexico.
- Immigration policies should be revisited to allow the inward flow of foreign experts and other measures to attract foreign talent, such as S&T experts, engineers, and other innovation specialists. Insofar as scientists are concerned, the scientific visa could be used in the European Union, or implemented in Belgium and the Netherlands, for instance, to facilitate the employment of foreign researchers.

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[32] Through public-private association, training centers in developed countries provide high-quality training programs to SMEs that are part of clusters (with ad-hoc programs) and may provide training and education to enhance cross-cutting skills, such as managerial skills or informatics.

- Connection with the Peruvian diaspora should be considered. These programs actively reach out to successful nationals engaged in STI activities overseas to collaborate with local institutions and researchers and to promote opportunities for short and long-term exchange visits. Linkages with Peruvian experts abroad could also help integrate the Peruvian innovation system with global research and innovation networks, including funding opportunities, participation in R&D, and innovation projects, among others.[33]

(iii) Research Policy and Modernisation of the Public Research Sector

Improving the public research system will require strengthening the public funding of institutions, such as IPIs and research universities, following new performance and mission-driven criteria and a revision of the governance and legal frameworks governing these institutions (see Box 1). This will entail:

- Increased institutional public funding of IPIs to allow their capacity development and expansion of technological competencies, human resource development, and updating their infrastructure and laboratories, in accordance with a strategic plan and revised mission.
- Reforming the law regulating IPIs as well as its organic laws. Improved governance of IPIs and research universities will require revision of institutional missions and responsibilities, and adoption of mechanisms for performance evaluation, accountability, and career development (acknowledging merit and innovation activities). This will also require a legal framework allowing and promoting linkages with other actors of the national innovation system through training and joint research programs, including PhDs, contract R&D and technology extension services.
- Strengthening mission-driven research in conjunction with industry and inter-institutional collaboration. Competitive funding for new mission-driven research programs such as centres of excellence (only public or public-private) can be useful to promote the development of critical mass in research and sectoral technological competencies. These initiatives, if effective, should benefit from financing for longer periods, such as 10 years as in the case of Chile, and a better link with PhD programs to ensure new PhD formation and training of young scientists.
- Construct an R&D infrastructure roadmap to coordinate decisions on future expansion and evaluation of inventory. This will also require creating a national code for the use of publicly funded infrastructure to facilitate the collective use of equipment across institutions.
- At universities, the “third mission,” which is technology transfer and entrepreneurship, needs to be accompanied by the appropriate autonomy and legal frameworks to entitle public institutions to engage in commercial activities. In this process, universities and

[33] An interesting example is the Unity through Knowledge Fund (UKF) program from Croatia, which supports a wide array of interactions, including collaborative projects and education programs, mobility projects, and short visits to Croatian S&T experts abroad, and vice versa.

public and research institutions should also develop technology transfer strategies and management offices.

Box 1: Public R&D and Technology Extension in Agriculture—the Success of Embrapa in Brazil

- One of the most extraordinary events in Brazil in the past 30 years has been the country's "agricultural revolution." In the 1970s, food scarcity was a concrete risk in a country experiencing rapid urbanisation and middle class expansion. One of the government's initiatives to address Brazil's stagnant agriculture sector and food scarcity was Embrapa (*Empresa Brasileira de Pesquisa Agropecuária*). Embrapa has succeeded in adapting, creating, and transferring technologies to Brazilian farmers for the past 30 years, helping transform Brazil into one of the world's largest food exporters.
- Pursuing a clear vision of recovering and boosting the agricultural sector, Embrapa has developed and transferred more than 9,000 technologies to Brazilian farmers. Researchers working at Embrapa have created over 350 cultivars and obtained more than 200 international patents. Specifically, Embrapa's new technologies targeted two main developments: first, they enabled the expansion of agriculture and cattle ranching activities into Brazil's Cerrado, one of the largest reserves of arable land in the world. Second, the development of seeds that were more suitable for tropical climate conditions (and the Cerrado's soil) helped increase land productivity for a number of crops, especially those originally grown in temperate regions.
- Embrapa's successful experience is at odds with the performance of many other public research institutes in developing countries, which often struggle to generate high-quality research and effectively transfer technology to farmers. Embrapa's success is due to four main factors:
    - *Adequate levels of public funding*. Embrapa's expenditures in the last 20 years, at around 1 percent of Brazil's agricultural GDP, compare well with figures of public spending on agricultural R&D in more developed countries, such as Canada, the United States, and Australia.
    - *Sustained investment in human capital*. Twenty percent of Embrapa's budget was invested in the education and training of its employees between 1974 and 1982 alone. Currently, three-fourths of Embrapa's 2,000 researchers hold a PhD. Furthermore, Embrapa strengthened its international linkages by establishing "virtual labs abroad" on three continents to institutionalise knowledge generation and exchange.
    - *A mission orientation and IPR policy*. Embrapa was created with "the mission to provide feasible solutions for the development of Brazilian agribusiness through knowledge and technology generation and transfer." Pursuing an open innovation system and IPR policy in the agricultural sector facilitated technology transfer, diffusion of new cultivars, and the filing of international patents.

Source: Correa and Schmidt (2014), Innovation Policy Platform Website.

(iv) Reinforcing Firm Innovation Policy and Sectoral Articulation

In order to promote innovation in firms, notably in SMEs, it is important to expand the national technology transfer system and support firms in the adoption of new technologies, including managerial skills and other forms of firm upgrading. There are at least three major venues for improving innovation in firms, particularly in SMEs:

- *Increase the public funding and capacity of CITEs following a performance-oriented funding approach, or eligibility criteria, and improve their governance and management capacity*. This will require an evaluation of the current functioning of the centres, their capacity and impact, and prospects for expansion. Private sector participation in governance and steering should be required under this new scheme. In line with international practices, effective technology extension schemes display a multiple partner governance, public-private or tripartite public, private, and academia, working with industry associations and collectivities of firms on long-term agendas for productivity enhancement (see Box 2).
- *Expand public support by funding and technical assistance to firm technology adoption and incremental innovation*. This will involve: (i) non-technological forms of firm innovation including training and learning projects, and development of managerial skills and adoption of new business models, such as manufacturing lean, just-in-time, quality management systems; (ii) ICT adoption and expanded use of technology extension services, such as adoption of new equipment, efficiency production techniques, standards and norms, quality testing and conformity tests; and (iii) assisting firms in the acquisition of human resources by facilitating links with the education and research systems and supporting hiring of new qualified personnel such as engineers and technical personnel. In deploying these efforts, we recommend the following actions:
    - Encourage firms' demands for upgrading and for incremental innovation by increasing awareness and knowledge of its impact and benefits. This will entail engagement in a nationwide campaign about their importance and engagement in demonstration exercises jointly with SME's and industry chambers and the implementation of pilot programs.
    - Ease access to public instruments. Develop simple and streamlined mechanisms of funding, such as grants, matching grants, or vouchers, especially for instruments targeting basic firm assessments and preparatory activities. This can be accompanied by assistance to SMEs in the preparation of applications, directly by agencies or by intermediaries, which can be industry chambers, as in the case of CORFO's network of intermediaries, or indirectly through a small grant.

Box 2: Technology Extension Programs—the Importance of Technology Transfer

Technology extension programs, also known as technology diffusion programs, provide a wide array of technology transfer services to SMEs to facilitate absorption and adaptation of technology (equipment, new managerial skills), improve their productive processes and products, increase quality standards, jumpstart new product development processes, or innovate via the transfer of new knowledge from scientific institutions to firms and industries. These services can be provided by public institutions, private, or public-private entities. In many countries, firms are directed to public financing (co-financing or credit lines) to finance these services. International experience points to several key features of high-impact organisations, such as: (i) (having) multi-source of funding matching public funding (federal and regional), own financing (revenue) and private sector participation; (ii) performance-based incentives ((e.g., achieving financial sustainability); (iii) (having a) network of extension consultants; (iii) multi-sector governance mechanisms (in board; overseeing; planning activities) involving universities/public research institutions, private sector, agencies and other relevant stakeholders; and (iv) monitoring schemes and medium to long-run technology agendas, allowing for a continuous improvement of productive capabilities of firms. Examples of manufacturing extension programs from developed countries include:

- *Japan*: Manufacturing extension programs in Japan are provided by some 262 Kohsetsushi Centres (Public Industrial Technology Research Institutes), which offer a range of Services to Japanese SME manufacturers including technology guidance; technical assistance and training; networking; testing, analysis, and instrumentation; and access to open laboratories and test beds.
- *United States*: The Manufacturing Extension Partnership focuses on direct interventions at the firm level to bolster the productivity, competitiveness, and innovation potential of SME manufacturers. With 1,300 technical experts operating out of over 60 regional centres, MEP provides resources and in-depth audits to SME manufacturers across the United States.
- *Germany*: The Fraunhofer Institutes (70 institutes) bring businesses and universities together to conduct industrially relevant translational research in specific advanced technology areas (such as IT, robotics, nanotech, sensors, and surface materials), perform many similar functions to MES agencies. The Institutes disseminate best manufacturing practices, promote technology and knowledge transfer, and support the development of advanced manufacturing processes and products.

Sources: Innovation Policy Platform and Andes, Ezell and Leal (2013), Beyond Mercantilism –Manufacturing Extension Programs in Latin America by ITFI.

- Create small and simple funding schemes (e.g., voucher with refunding) to promote a productivity culture in SMEs by supporting firm assessments (e.g., technology and managerial audits), and preparatory activities to innovation (e.g., definition of innovation projects).

- Review current instruments targeting firm innovation and strengthen them (funding and promotion), consolidate them when duplication exists, and strengthen funding for those that are proven effective.
- Widen the palette of instruments to support firm incremental innovation and different types of firms. Consider the use of credit lines with subsidised rates and vouchers to promote incremental innovation and technology acquisition in SMEs. Support acquisition of human resources. Consider a co-funding scheme to encourage hiring of engineers and technical staff, and foreign specialised personnel. Review the adequacy of measures that facilitate firms' access to sources of technical knowledge abroad and hiring of foreign professionals.

➢ *Enhance vertical policies targeting innovation in industries and value chains.* This involves considering funding support to facilitate innovation sectoral agendas and industry coordination, including collaborative activities addressing sector-level needs (see Box 3). Financing support for sectoral innovation initiatives (e.g., clusters and/or innovation networks) could cover a wide range of activities: industry-level studies and diagnostics, technology road-mapping and prospective assessments, identification of regulatory bottlenecks; network organisation, R&D activities, training and upgrading, and others.[34]

➢ *Consider mechanisms to encourage firm upgrading and innovation by linking firms with markets.* This means linking support for firm innovation to local or international demand and in collaboration with customers, such as large firms, multinationals, and the state, or procurement programs. The use of local supplier development programs has been proven effective, along the lines of the Czech Program for Supplier Development from the mid-1990s, the Partnership for Transformation program (Singapore SPRING), formerly known as the Local Industry Upgrading Program, and the Chilean Supplier Development Program.

(v) Industry-Science Interaction

Improving industry-academia interactions to make better use of knowledge in society and the economy entails improving governance and the legal stature of institutions to engage in such transactions, as well as opening the research (and university) system to different forms of knowledge transfer. Important means to promote industry-science interactions include:

➢ Industry involvement in curriculum design at universities and vocational training institutes

➢ Joint industry-academia education and training programs

[34] These initiatives should address collective innovation bottlenecks and innovation development and facilitate convening key actors relevant to the sectoral innovation process: public research, technology and education organizations, regional agencies, and intermediary organizations (e.g. finance and banking; technology organizations).

- Mobility of researchers and technicians in both directions—between academia and industry
- Master's and PhD theses involving industry or jointly conducted with industry
- Joint research and shared infrastructure programs between public and private institutions
- Provision of clear legal frameworks entitling organisations and researchers to participate and benefit from the creation and exploitation of IPRs resulting from publicly funded research, and recognition of inventors in revenues.
- Incentives should also be reflected in the way researchers and public research organisations are evaluated and financed. Performance in the evaluation of individual scientists should acknowledge participation of researchers in technology transfer activities.
- Supportive intermediary organisations in charge of promoting, training, and assisting stakeholders in technology transfer activities.
- Funding schemes (pre-seed) for proof of concepts, prototype development and feasibility studies, market, and technical studies, and IPR protection.

Box 3: Sectoral Innovation: The Industry Growth Centers Initiative—a new policy direction for Australia

The Industry Growth Centers Initiative (the Initiative) is the centrepiece of the government's new industry policy direction and part of the Industry Innovation and Competitiveness Agenda. It will lift competitiveness and productivity by focusing on areas of competitive strength. The Initiative will enable national action on key issues such as deregulation, skills, collaboration, and commercialisation. It will drive excellence, not dependence, and create an economy that ensures Australia's ongoing prosperity.

The Initiative is ongoing with $225 million in Australian Government funding over the four years from 2015/16 to 2018/19. Industry Growth Centers are being established to deliver the Initiative in five growth sectors in which Australia already has a competitive advantage: (i) advanced manufacturing; (ii) food and agribusiness; (iii) medical technologies and pharmaceuticals; (iv) mining equipment, technology and services; and (v) oil, gas and energy resources. The Growth Centers will also facilitate engagements between enabling services and technologies, such as information and communications technology, where they provide essential and direct support to the growth sectors. While the Growth Centers will be flexible in their approach to addressing barriers to success, they will be tasked with looking at four broad themes:

- Identifying regulations that are unnecessary or over-burdensome for the key growth sectors and impede their ability to grow, and suggesting possible reforms;
- Improving engagement between research and industry, and within industry, to achieve stronger coordination and collaboration of research and stronger commercialisation outcomes in the key growth sectors;
- Improving the capability of the key growth sectors to engage with international markets and access global supply chains; and
- Improving the management and workforce skills of key growth sectors.

Overarching activities that all Growth Centers will complete include: Development and implementation of a roadmap to lift sector competitiveness; Provision of advice to Government on how to best reduce regulatory burden within their sector; and Development of annual industry knowledge priorities to help inform the research sector of industry needs and commercialisation opportunities.

Source: http://www.business.gov.au/advice-and-support/IndustryGrowthCentres/

(i) Governance and Policymaking

- Establish an M&E system allowing for the measurement of progress and results to report to society as well as providing the system with alerts and lessons to improve policy learning and timely adjust policy programs.
- Strengthen the national statistical base for science, technology, and innovation. This requires developing indicators and methodologies in line with international standards such as the OECD R&D Frascati Survey for public research organisations and the private sector as well as continuing the Innovation Survey (OECD Oslo Manual) and expanding it to services and primary sectors.
- Improve coordination of policy programs through: (i) horizontal mechanisms such an inter-ministerial committees for innovation; and (ii) interactive mechanisms across implementing agencies, such as joint implementation of certain programs, bilateral participation in evaluation panels, and (iii) improved management and coordination through the use of shared application procedures and information databases, such as sharing online follow up on firms' profile and use of programs, monitoring and results; as well as conceiving a first-stage registration form, and others.
- Undertake a periodic public expenditure review of science, technology, and innovation policies, in order to identify policy disbursements trends, impact, and efficiency of policy programs.

(ii) Regional Innovation Systems and the Canon

- Strengthen institutional capabilities of subnational authorities so that they can define and implement suitable projects while ensuring coherence at the national level.
- Strengthen and develop regional technology extension centres.
- The use of Canon Resources should be expanded to broader regional innovation needs.
  - This can involve supporting the creation of regional innovation networks and regional innovation agendas supporting cluster and industry development.
  - Supporting basic forms of innovation and productivity development in firms and industries through co-financing and grants. This should include support to training, firm technological upgrading and equipment, and technology services.
- In deploying these efforts, new innovation initiatives at the regional level should coordinate with regional economic agendas and agencies

(iii) Complementary Measures

- Continue reinforcing the National Quality Systems.
  - This includes strengthening the national metrology system, including its capacity, equipment, and raining, accreditation systems and its coordination, and a more active participation in international quality organisations.
  - This also includes stimulating the demand for such services through increased promotion, articulation with innovation agendas in value chains and sectors, and by matching financial support for SMEs to access these services.
- Improve the national IPR system, its effectiveness and use by firms. This will entail:
  - Improving enforcement of IPRs.
  - Strengthening institutional capacity of the IPR Department, which involves improving registration and administrative capacity, information platform development, data digitalisation, and online service development.
  - Engage in promotion and outreach program to encourage firms' use of IPRs, including trademarks, copyrights, design and patent rights, and the protection of traditional knowledge and geographic indications.
    - Enhance the use of IPRs in national and regional innovation strategies. For instance, geographical indications and collective trademarks could support rural business development and producers' associations.
    - Facilitate broader use of the IPR system through regional services and invest in awareness-raising campaigns in regions. Simplified IPR registration procedures and fee discounts or funding incentives, e.g. co-funding instruments for patent protection should also be considered.

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