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DISCUSSION PAPER

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DISCUSSION PAPER

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CONTENTS

ABSTRACT

This paper examines Brazil's position in research, technology transfer and innovation activities relative to peer economies and a selected group of developed countries. It reviews the governance of the research and innovation systems, the current policy landscape, and the results achieved by current policy programs. Based on this analysis and supplemented by discussions from a national seminar on Brazil's innovation policies, the paper identifies key outstanding challenges to foster a more effective national innovation system and improved innovation performance by the business sector. The paper concludes with suggestions for public policy reforms for business innovation in Brazil, focusing above all on more effective market competition as a necessary condition for state support to innovation to succeed. Other priority areas include improved public research and industry collaboration, greater firm innovation and demand effectiveness, better policy coordination, and regular Public Expenditure Reviews and other forms of monitoring and evaluation.

A previous version of this paper served as background for a national seminar on innovation for productivity growth held in Brasilia on July 1-2, 2015 organized jointly by Ipea, the Brazilian Industrial Development Agency (ABDI), the World Bank, and the Organisation for Economic Co-operation and Development (OECD). This version integrates key messages from the discussions, plus helpful comments received from Xavier Cirera, Paulo Correa, Donato De Rosa, Martin Raiser and Frank Sader. The views herein expressed are entirely those of the authors. They do not necessarily represent the views of their institutions.

Keywords: Innovation policy, Brazil, productivity**.**

1 INTRODUCTION

The purpose of this paper is to provide information and insights to nourish a discussion that helps strengthen the effectiveness of public policies for innovation in Brazil. The paper provides elements for reflection particularly regarding the international position of Brazil in innovation activities, and the results achieved by current policy programs and approaches. It identifies some important challenges that remain in the national innovation system and in public policies towards innovation.

The paper is an outcome of the international seminar "Strengthening innovation for productivity growth in Brazil – Towards a renewed agenda of policies for innovation" held in July 2015 in Brasília. The seminar was organized by the Institute for Applied Economic Research (Ipea), the Brazilian Industrial Development Agency (ABDI), the World Bank and the Organization for Economic Cooperation and Development (OECD). It was attended by leading experts in innovation policies from universities, government and industry. The topics discussed included structural conditions for increasing productivity in Brazil, recent experiences in innovation policies, and the role of science-industry collaboration. A draft version of the paper was shared with seminar participants, who reviewed and discussed the issues addressed.

A key message of this study is that current innovation policies are likely to be ineffective and have limited impact unless more is done to simultaneously strengthen market competition in Brazil. International experience and microeconomic research suggest that market competition and international openness are essential to pressure entrepreneurs to allocate their talent and investment resources to continuously upgrade products and processes, and to enable businesses to learn from the evolving global technology frontier and commercialize that learning through larger markets.

The importance of market competition as a necessary condition for state support to innovation to succeed is not always fully appreciated in Brazil. Indeed, competition, particularly from abroad, is sometimes seen as detrimental to the development of domestic enterprise. Brazil's past record of fast economic growth in the 1960s and 1970s under a regime with limited market competition and high barriers against foreign trade would seem to bear out the skepticism. Yet, similar policies of weak market competition supported by public expenditures directed at favored, less productive firms, international entry barriers including very high tariff and non-tariff barriers and complex regulations limiting market access have not had the same effect in recent years. How can we account for this difference? Schumpeterian growth theory may provide an answer: in this framework, technical progress is driven by creative destruction, whereby new innovations spurred by market competition replace older technologies.[1] However, the effect of competition is ambiguous: when existing firms are far away from the technology frontier, increasing competition could actually discourage them from innovating because they don't feel they have a chance to win and survive. For firms that are close enough to the frontier, the effect is the opposite: only thanks to competition will these firms innovate and pull the rest of the economy along with them. Failure to subject such firms to competitive pressures may lead them to get complacent, or indeed spend resources on lobbying government to keep their protected status intact.

This framework can be used to look at the impact of trade liberalization on innovation and productivity growth. Liberalizing trade increases the market for successful innovations and therefore the incentives to innovate through both a scale effect and a competition effect. But free trade at early stages of development may lead to the disappearance of domestic producers, as claimed by infant industry arguments. The non-linear effect of competition may explain why trade restrictions have become increasingly detrimental to growth as Brazil has approached the global technological frontier.[2] Public support policies have been largely ineffective due to the absence of sufficient market competition and opportunities for global learning, in addition to remaining gaps in the availability of skills to utilize and adapt new technologies. Injection of public funding to R&D activities has therefore not been translated into commercial innovation activities by businesses. These factors, in addition to policy biases in some sectors towards R&D-based technological innovation at the expense of sufficient support to technological diffusion and incremental innovation, seem to be at the heart of the persistent innovation shortfall of Brazil compared to peer and OECD economies.

The first part of the paper presents a review of key indicators related to broadly-defined innovation, including technology adoption at the firm and country level. We examine where Brazil stands in comparison to peer economies and a selected group

1. For a compelling framework linking market competition to growth through creative destruction, see Aghion, Akcigit and Howitt (2014).

2. Acemoglu, Aghion and Zilibotti (2006) show that low degrees of trade openness become increasingly detrimental to growth as countries approach the technological frontier.

of developed countries. We distinguish indicators of technology adoption and measures of incremental, catch-up innovation from indicators related to frontier innovation and more R&D-driven forms of innovation outcomes. In the second part, we discuss major constraints to firm innovation based on results from Brazil's national innovation survey and complementary data. The third part discusses the impacts, shortcomings and areas for improvement of recent policy developments related to innovation in Brazil. While this paper is far from exhaustive given the rich and wide variety of instruments and programs for innovation currently in place in Brazil, we intend above all to highlight some remaining important policy gaps, with a particular focus on the absence of sufficient market competition and trade openness. A final section presents some outstanding issues for public discussion and consideration by policymakers.

2 INNOVATION PERFORMANCE OF BRAZIL: AN INTERNATIONAL COMPARISON

Brazil has made substantial economic and social progress in the last decade, which contributed to reductions in poverty and inequality. Despite the fact that it remains one of the most unequal countries in the world, Brazil has made significant progress on inequality reduction: the poverty headcount ratio (% of population) decreased from 21 percent in 2005 to 8.9 percent in 2013 and extreme poverty fell from 10 percent to 4 percent of the population between 2001 and 2013. Thanks to a strong export performance, Brazil was able to generate sizable trade surpluses for most of the past decade – on average US$ 32.5 billion per year between 2002 and 2008.

Yet Brazil has experienced weak productivity growth for the last 60 years. In most industries, especially in manufacturing and services sectors, productivity growth has been very low. A wide dispersion across firms within each industry prevails, reflecting difficulties in the allocation of economic resources from less to more efficient firms both across and within industries. In addition, regional disparities remain high in spite of important achievements through government investment and social programs to improve cross-country socio-economic conditions. This is linked to the challenge of improving coordination among government agencies at the federal, state and local levels to achieve a higher impact through more effective interventions.

Brazil now faces the challenge of enhancing economy-wide productivity-driven growth to secure and expand the social achievements of the last decade. Brazil needs to re-launch its productive transformation and move from an economy still based too much on low value added in its primary sector industries to one based more on higher value added knowledge upgrading in all industries across primary, manufacturing and service sector industries. Further, the major factors that contributed to labor income growth in the last decade, in particular improved terms of trade related to commodities, have faded. Recent labor income growth trends are not economically sustainable in the long term without increases in productivity.

To achieve productivity-driven growth, improving the innovation performance of the business sector is fundamental. Innovation is at the heart of countries' and firms' drives to raise productivity and economic growth. International experience has shown that growth is driven not only by physical and human capital accumulation, but also, most importantly, by knowledge capital accumulation and innovation, including catch-up (new to the firm) and frontier (new to global markets) innovation. Innovation is here defined as a broad concept that includes not only the generation and commercialization of new-to-the-world ideas but also the diffusion and adoption of existing new-to-the-firm knowledge by all firms, adapting that knowledge to local context in the form of new products, processes, and organizational, marketing and business models.

At the firm level, innovation should lead to a more efficient use of resources in ways that also better meet changing consumer needs. This is not an automatic process. Business innovation depends on a range of factors including market conditions (demand and competition), the ability of firms to learn and build capacities based on existing and new global knowledge (skilled managers and workers coupled with ease of access to learning from more advanced technologies embedded in global goods and services, physical capital and talent), and the ease of appropriation of innovation returns (related, among others, to intellectual property protection and enforcement).

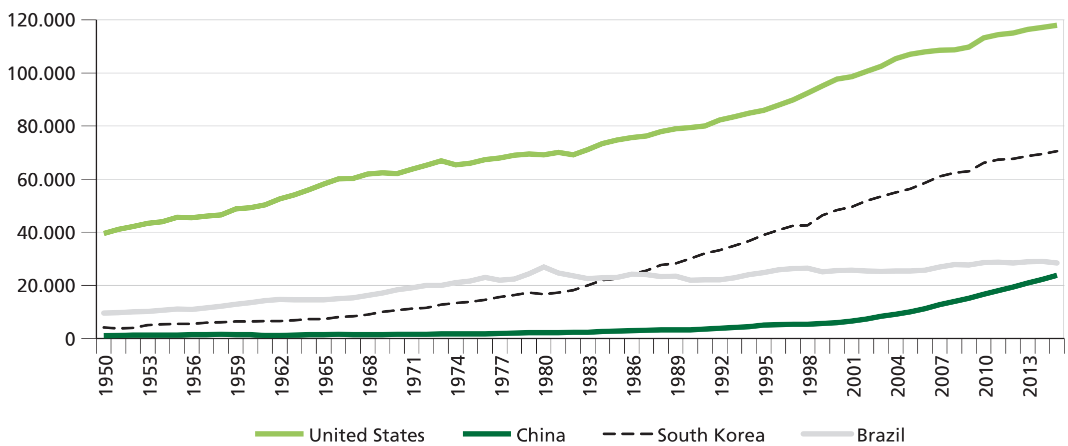
Innovation activities are not produced in isolation within organizations. They are increasingly dependent on external factors (and sources of knowledge) and their success depends upon effective interactions with a broader innovation ecosystem (the National Innovation System or NIS; initiated by Freeman (1987) and Edquist (2005)). More generally, innovation investment decisions (and their returns) depend upon enabling framework and business conditions allowing firms to enter into markets, compete and exit (quickly) if necessary, and access competitive sources of knowledge and technology from both domestic and international markets.

As we will see next, the Brazilian business sector is not investing as much as peer economies and OECD countries in several critical areas of innovation – including in R&D, other intangible assets, and most importantly, in technology adoption. The benchmarking exercise demonstrates that Brazilian firms are trailing behind peers from other emerging and developed economies in several aspects of innovation. Incentives to innovate by the business sector are affected by weaknesses and deficiencies in the framework conditions dissuading such investments. The review also indicates that obstacles to innovation appear markedly more accentuated for small and medium sized enterprises (SMEs) than for large companies.

2.1 Overall performance

Brazil was characterized by economic dynamism and social progress over most of the past decade. Brazil grew at an average rate of 4.4 percent over the period 2004-2010 compared to 1.9 percent in the previous seven years. Over the period 2003 to 2013, over 26 million people were lifted out of poverty and inequality was reduced significantly (the Gini coefficient has fallen from 0.59 in 2001 to 0.53 in 2013). Thanks to a strong export performance, Brazil was also able to generate sizable trade surpluses for most of the past decade – on average, US$ 18.01 billion per year between 2004 and 2014.

GRAPH 1
Labor productivity per person employed in 2014 US$ (converted to 2014 price level with updated 2011 PPPs)



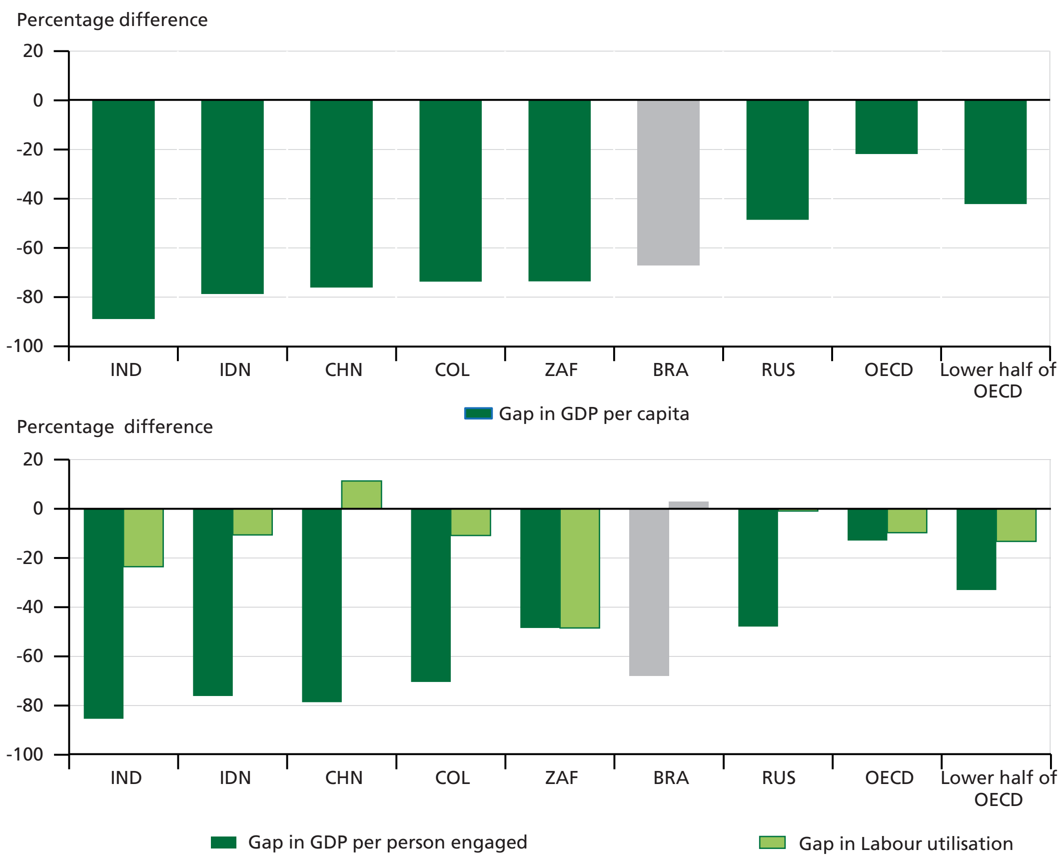
Source: The Conference Board (2015). Available at: <https://goo.gl/LLsckb>.

Yet, productivity has not been improving at the same pace as economic growth. graph 1 shows that the gap in productivity (measured as GDP per person employed) with respect to the United States was increasing after 1980. Brazil had a labor productivity of US$ 28,500 in 2015 while the United States, Germany and Japan had a productivity level of US$ 117,900, $ 87,900 and $ 73,200 respectively (measured in PPP terms at 2014 price levels). Even against other leading developing countries, Brazil shows a lower performance. For instance, the labor productivity levels in South Korea, Russia, Malaysia and South Africa were respectively US$ 70,500, $ 48,300, $ 57,100 and $ 42,500. Another way of showing the importance of productivity for Brazil's future economic growth is graph 2 that breaks the current gap in income levels with OECD countries down in the contributions of labor utilization and labor productivity. It shows that the gap in income levels is entirely due to the relatively low level of labor productivity of the Brazilian economy.

GRAPH 2

Gap in GDP per capita, in GDP per person employed and in labor utilization (2014)

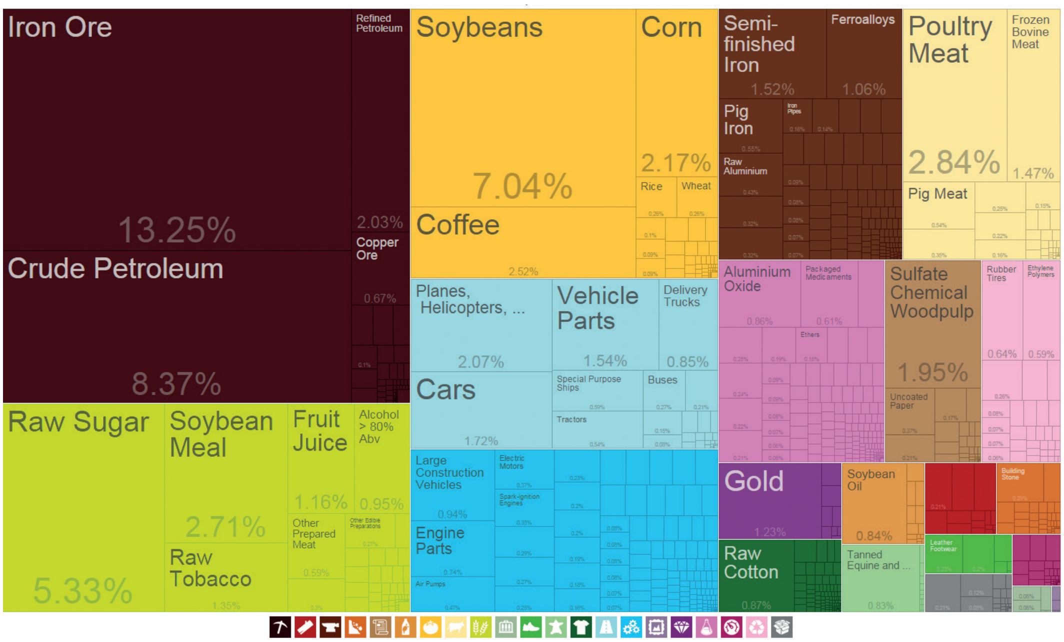
(Percentage points differences with respect to the top half of the OECD)



Source: OECD, Productivity Database. Available at: <https://goo.gl/eU3nTo>.

The industrial composition and export basket of the Brazilian economy also indicate difficulties to move towards higher levels of sophistication. The complexity of an economy has been shown to be related to the multiplicity of useful knowledge embedded in it.[3] According to this definition, competitive countries are those showing a high diversification of their export basket. Brazil is ranked 56th with an Economic Complexity Index (ECI) of 0.315, well below developed countries, and emerging economies such as India, South Korea, Mexico or Russia. Moreover, Brazil displays deterioration in its level of economic complexity, shrinking drastically between 1995 and 2011.

GRAPH 3
Products exported by Brazil (2012)
(% of the total)



Source: Observatory of Economic Complexity, MIT. Available at: <https://goo.gl/RZBIGg>.

3. According to the Observatory of Economic Complexity, "The complexity of an economy is related to the multiplicity of useful knowledge embedded in it. Because individuals are limited in what they know, the only way societies can expand their knowledge base is by facilitating the interaction of individuals in increasingly complex networks in order to make products. We can measure economic complexity by the mix of these products that countries are able to make. Some products, like medical imaging devices or jet engines, embed large amounts of knowledge and are the results of very large networks of people and organizations. These products cannot be made in simpler economies that are missing parts of this network's capability set. Economic complexity, therefore, is expressed in the composition of a country's productive output and reflects the structures that emerge to hold and combine knowledge". Available at: <http://atlas.media.mit.edu/en/resources/economic_complexity/>.

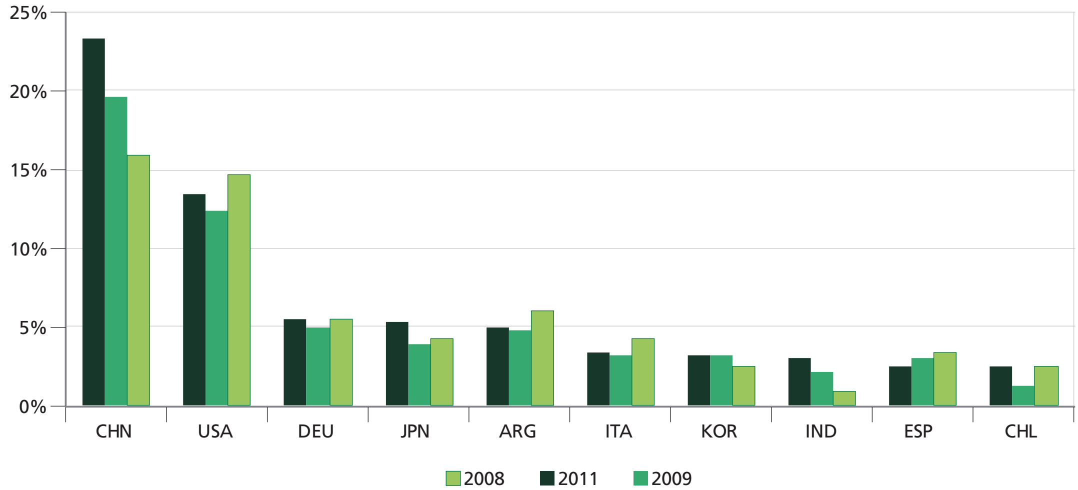
Statistics on exports show the predominance of low technology industries in Brazilian international trade. Iron ore, crude petroleum, soybeans and raw sugar represent more than 1/3 of Brazilian exports. Brazil is the top exporter of raw sugar, coffee, sulfate chemical, wood & pulp, poultry meat, frozen bovine meat, fruit juice, raw tobacco, alcohol > 80% ABV, flexible metal tubing, and other metals. Brazil was also able to conquer specific market niches in the aeronautics and metal mechanics industries but not sufficiently to offset the huge weight of raw and semi-raw materials (graph 3).

The manufacturing sector has decreased its participation in national value added, from 31.3 percent in 1980 to 14.6 percent in 2010. Within manufacturing, there has been a reallocation of resources from the traditional segments (labor intensive and natural resource-based) to the more technologically sophisticated ones (science and knowledge-based).[4]

Brazil's integration in global value chains remains limited, partly due to the lack of well-developed regional value chains in Latin America. Brazilian manufacturers had the lowest levels of export orientation amongst BRIICS and G7 economies in 2011, with less than one-fifth of total value-added destined for export markets – down from close to one-third in 2005 (OECD-WTO TiVA at OECD.stat database). Brazil's major import and export markets remain outside of Latin America, excluding Argentina, with China alone directly importing one-quarter of all Brazil's intermediate exports in value-added terms in 2011 (graph 4), pointing to underdeveloped regional value chains. However, close to half of all exports reflect services content (and one-third of manufacturing exports reflect services content). This suggests the importance for Brazil's performance in international trade, over the coming years, to develop higher productivity, more competitive services.

4. See Nassif, Feijó and Araújo (2013).

GRAPH 4
Brazil's domestic value added embodied in intermediate exports (2008, 2009, and 2011)
(% of total intermediate exports, in value added terms)



Source: OECD.stat. Available at: <https://goo.gl/W63CsR>.

Brazil's high-technology industries are expanding and this will eventually translate into higher exports if goods are internationally competitive. Over the period of 2003 to 2013, Brazil's high-technology manufacturing industries grew more than twice as fast as the average for all developing countries, excluding China. Pharmaceuticals, aircraft and spacecraft led this growth. Much of this expansion has been driven by increased foreign multinational activities that seek to capitalize on Brazil's growing consumer market. Brazil is a major global producer of aircraft and has invested heavily in R&D for spacecraft and satellites.

In terms of innovation performance, according to several indicators, Brazil performs in the medium range behind peer economies such as Russia and China. Brazil ranks in 61th place in the Global Innovation Index far behind Ireland (11th), China (29th), Portugal (32th) and Russia (49th).[5] Out of the world's top 2000 R&D performing firms, only eight are Brazilian, although this is more than in other large emerging economies, e.g. Mexico (1), Russian Federation (4) and South Africa (1) (Dernis et al., 2015).

5. The Global Innovation Index 2014. Available at: <https://goo.gl/hsmi2f>.

The nature of innovation by Brazilian firms is mostly catch-up rather than frontier innovation. Most of the innovations introduced by Brazilian businesses consist of the commercialization of adaptive and incremental "new to the firm" or "new to the national market" existing technologies, hence are appropriately classified as catch-up rather than more radical frontier or "new to global markets" innovations (graph 5).

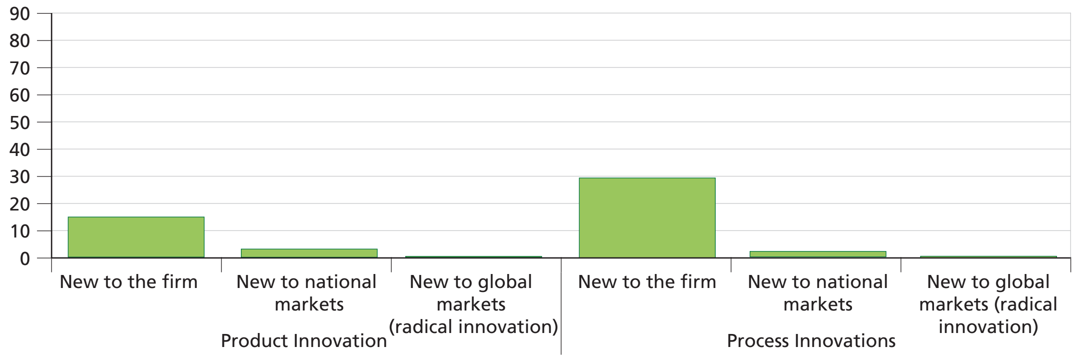
In terms of types of technological innovation, process innovation is more frequent than product innovation. Process innovation can lead to productivity gains that enable firms to produce the same level of output with fewer inputs, or more outputs with the same inputs. Process innovation can therefore have direct labor-saving impacts, though these can be counterbalanced by indirect expansion impacts when the cost reductions spur lower prices that drive higher demand and greater output. The employment effects of product innovation are typically less ambiguous, generally stimulating demand for the firm's output – though like process innovation, the impact on aggregate employment depends on the extent of demand diversion from substitute products of other firms. Interestingly, there seems to be an increase in the novelty of process innovations over time (that is, such innovations are being reported as not only new to the firm but also new to the national market), though the changes in levels remain low.

Overall, innovation-related outputs as reflected in patents are low. Between 2000 and 2010, Brazil's share of world patents granted by USPTO remained stable, at around 0.07 percent. In a comparison with 75 other countries, Brazil ranked 54th in 2010 in terms of resident patent applications as a share of GDP, at 1.38 patents per US$ billion (WIPO, 2013). And in terms of patents per population, Brazil ranked 55th among 82 countries (13.9 patents per million inhabitants). In both cases, Brazil ranked below the average country rank. And only 6.1 percent of national innovative firms applied for patents over the 2006-2008 period (Ferrero Zucoloto et al., 2013); this share reached 26.4% for foreign firms and 36.5 percent for joint national and foreign-owned enterprises.

GRAPH 5

The nature of technological innovation in Brazilian firms (2009-2011)

(all companies in the economy, in %)



Source: PINTEC/IBGE. Available at: <https://goo.gl/HJUK8F>.

Although patenting has been growing over the past decade, it remains largely restricted to a select number of high-performing industries such as aerospace, oil and gas, agroindustry and cosmetics. It is also confined to a small number of large Brazilian firms and multinational companies. Research networks around Embraer (aircraft technologies), Petrobras (oil and gas) and Embrapa (agriculture) have had significant patenting outputs. But these exceptional cases are characterized by particular features, and the trend over time for patents for Brazil remains fairly flat (graph 6). The successful research networks have achieved an important degree of embedded autonomy, and have built on a long-term involvement of both government and business. These schemes have been difficult to replicate to other industries and to extend to SMEs more broadly. The success of agriculture innovation and technology transfer led by Embrapa is a particular case of a sectoral innovation system with a leading role by a public sector institution. It holds important lessons for other industries. Embrapa's success is due to four main factors (Correa and Schmidt, 2014).

1) 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 public spending on agricultural R&D in more developed countries, such as Canada, the United States, and Australia.

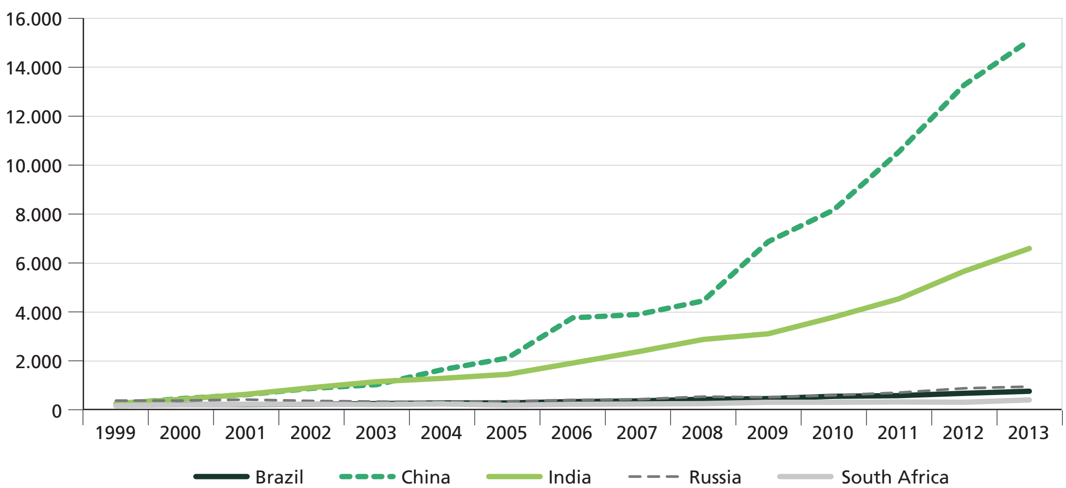
2) Sustained investment in human capital: 20% of Embrapa's budget was invested in the education and training of its employees between 1974 and 1982 alone. Currently, 3/4 of Embrapa's 2,000 researchers hold PhDs.

3) International collaboration and research excellence. From the beginning, researchers were drawn from leading universities, setting a high standard of research excellence. Furthermore, Embrapa strengthened its international links by establishing "virtual labs abroad" on three continents to institutionalize knowledge generation and exchange.

4) 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 an IPR policy facilitated technology transfer, diffusion of new cultivars, and the filing of international patents.

GRAPH 6

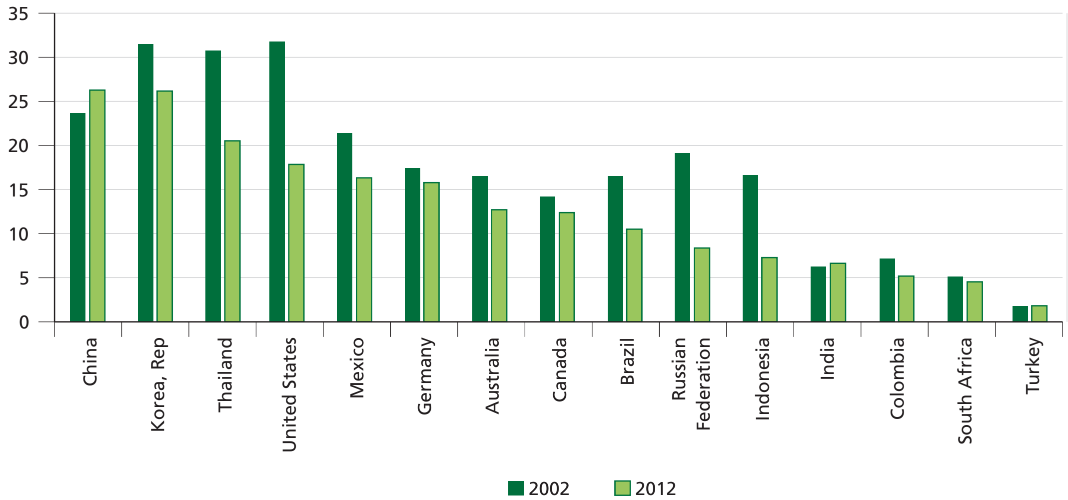
Patents applications to the USPTO, selected countries (1999-2013)



Source: USPTO. Available at: <https://goo.gl/OXUygF>.

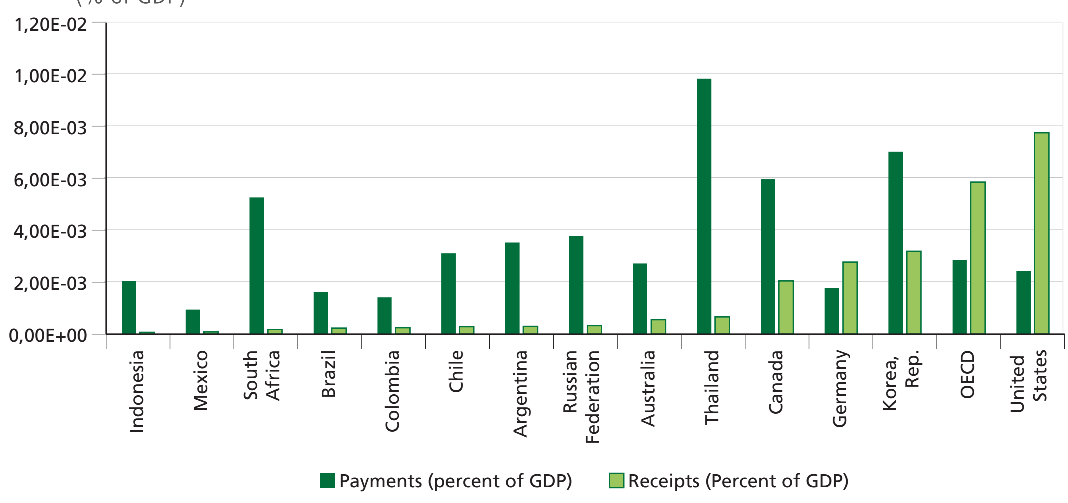
Brazil's relatively weak economy-wide frontier innovation performance is also reflected in the intensity of technology-intensive exports in total manufacturing exports, and of technology receipts and payments. In 2012, only 10 percent of manufactured goods were high technology-intensive products, whereas in China and Korea this figure was 20 and 26 percent, respectively. Mexico also shows a higher technological intensity in manufactured exports at 16 percent (graph 7). As well, Brazil performs lower than most in terms of the intensity of payments and receipts in technology as registered in the technology balance of payments. These are indications of how much intellectual and technology services are imported to and exported from Brazil (graph 8).

GRAPH 7
High Tech exports, selected countries (2002-2012)
(% of exports)



Source: World Development Indicators. Available at: <https://goo.gl/Wrv54r>.

GRAPH 8
Technology payments and receipts, selected countries (2012)
(% of GDP)



Source: World Development Indicators. Available at: <https://goo.gl/wf2uxX>.

The increase in university patenting in Brazil appears mainly driven by policy changes rather than market incentives. The increase in patenting closely matches the policy reforms initiated in 1996 and 2004, which provided further incentives for researchers and institutions to own and commercialize intellectual property rights (IPRs) resulting from research. The law of 2004 also made mandatory the creation of Technology Transfer Offices (TTOs). During the period 1990-2001, there was a 30-fold increase in applications and 4-fold increase in grants, reflecting the increased scientific production by Brazilian research institutions.

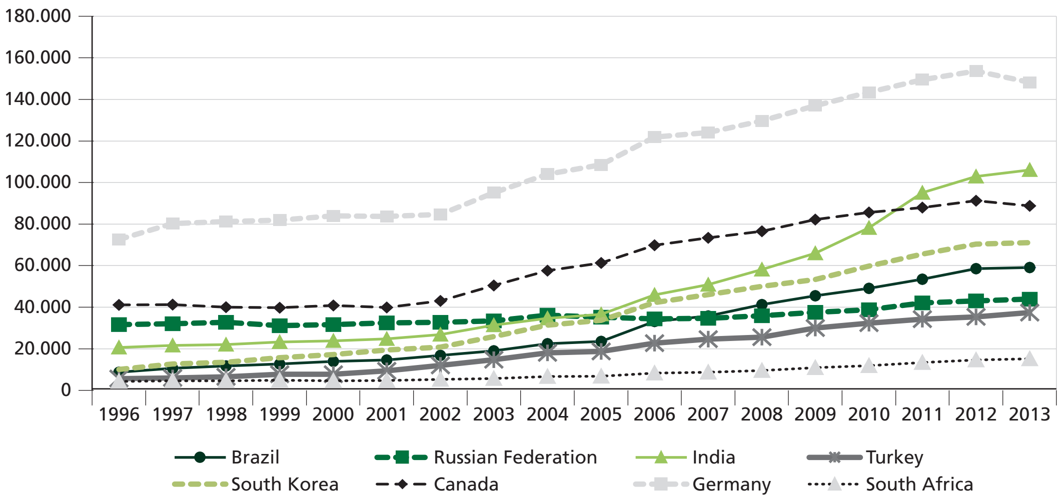
However, there are concerns about the quality of patent filings and their productive relevance and use in the economy. Most Brazilian research organizations lack a strategy for technology transfer (and patenting) and selectivity in what to patent. They also have a poor use of technical and market assessments to understand what the market needs.[6] Accordingly, rates of technology transfer and commercialization, while difficult to observe, remain low. A significant proportion of Brazilian academic patent applications are not transformed into grants and few patentability assessments are made at the TTOs. Accordingly, the increased impetus for patenting has been motivated by reputation concerns and the increased perception of patenting as a measure of science performance (Maia de Oliveira and Velho, 2010).

In terms of both resources for basic and applied science and for related outputs, particularly articles published in high-quality journals, national figures remain low compared to the OECD average. Several deficiencies of the research system remain, with research excellence standards only applying to a small number of institutions. High-quality research remains largely concentrated in a few universities and regions, and a huge disparity prevails in terms of the allocation of S&T inputs and outputs across regions.

6. See Maia de Oliveira and Velho (2010). For China, Guo (2007) argues that the rapid growth in university patenting in China reflects in part the increased propensity by researchers and institutions to use patents as a way of enhancing their reputations rather than for actually transferring technology.

Although scientific performance has improved in Brazil. In 2010, Brazil produced 2.12 percent of total scientific publications globally, a huge increase from below 1 percent in the 1980s (graph 9). A key issue, though, is that most researchers and new S&E specialists continue to be absorbed by the public sector rather than joining the private business sector.

GRAPH 9
Scientific publications (total number) over time, selected countries

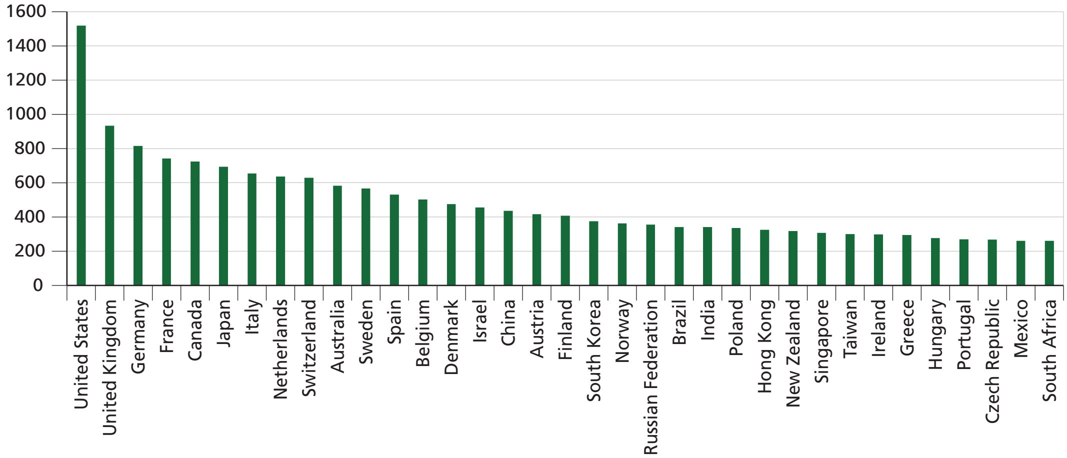


Source: SCImago Online Database. Available at: <https://goo.gl/3hibHN>.

The quality of science, however, remains far from the average of developed countries. In terms of the H-index for publications (citation impact), Brazil is behind China, South Korea and Russia, but ahead of India and South Africa over the period 1996-2013 (graph 10). Medicine and biochemistry are the most influential research areas published by Brazil. Another indication of Brazil's weak quality of research is its low share of publications considered as highly cited (OECD, 2015b): only 6.7 percent of scientific papers are part of this group, while OECD countries such as Germany, United Kingdom, Canada, or Australia all report percentages larger than 10 percent of their total volume (graph 11).

GRAPH 10

H-Index, quality of science, selected countries (1996-2013)

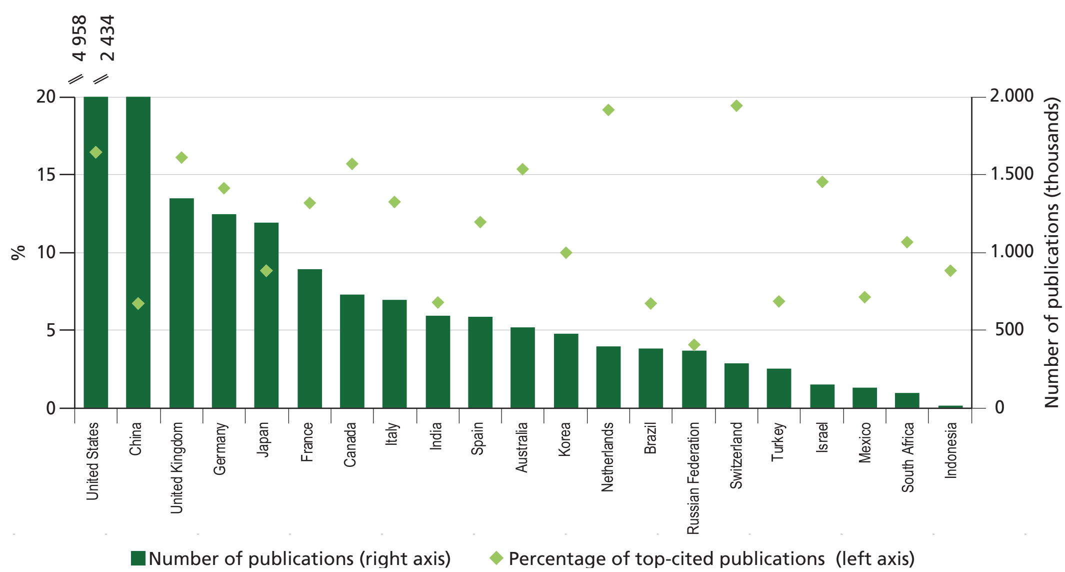


Source: SCImago Online Database. Available at: <https://goo.gl/BXsGBU>.

GRAPH 11

Quantity and quality of scientific production (2003-2012)

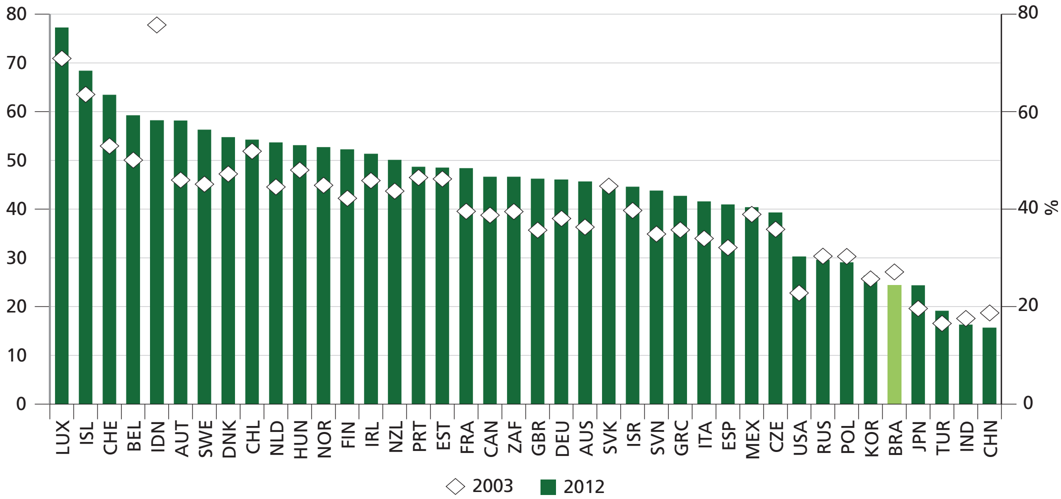
(Number of documents and percentage among world's 10% most cited)



Source: OECD (2015b), SCImago Online Database. Available at: <https://goo.gl/twhVcO\>. Compendium of Bibliometric Science Indicators. Available at: <https://goo.gl/K6iXWe>.

In addition, there is a need for greater integration into global collaborative networks of S&T research (see graph 12). Brazil's absolute and relative number of co-authorships with international partners in scientific publications, although growing and higher than other emerging economies (such as India or Russia), continues to trail developed economies. Between 2000 and 2013, this share has been decreasing (from 29 to 25 percent).[7] In larger developed countries, international co-publications represent about 50 percent of scientific publications: in 2013, this share was 45 percent in Germany and 47 percent in Canada.

GRAPH 12
International scientific collaboration (2003 and 2012)



Source: OECD (2015b), SCImago Online Database. Available at: <https://goo.gl/hu0iN3>. Compendium of Bibliometric Science Indicators. Available at: <http://oecd/scientometrics>.

2.2 Technology and innovation efforts

In this section, we present an overview of more specific indicators of innovation and analyze how Brazil compares with other economies (OECD and emerging countries). We distinguish catch-up innovation activities from those related to frontier innovation (R&D based), including public investment in science and industry-science collaboration.

2.2.1 Intagibles and catch-up Innovation

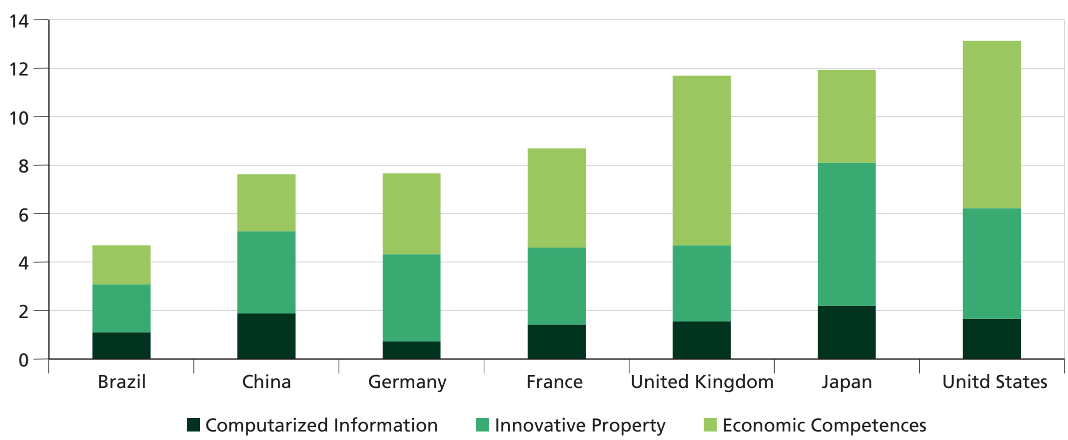
Firms in Brazil are not investing in intangible assets as much as their peers in leading countries.[8] Spending on intangibles by Brazilian firms averaged around 4

7. SCIMAGO (2014) online database based on SCOPUS (Elsevier) bibliographic data.
8. See Dutz et al. (2012).

percent of GDP between 2000 and 2008; this is considerably less than in Japan, the United Kingdom and the United States but roughly similar to Italy and Spain (graph 13). The gap between Brazilian firms and their United States peers is largest for economic competencies such as brand equity and organizational improvements and for R&D. US firms spend about ten times as much on organizational capital, three times as much on brand equity and about four times as much on R&D than Brazilian firms.

The gap with other OECD economies is also large for other forms of innovative property, in particular new architectural and engineering designs. A comparable measure based on surveys of manufacturing enterprises yields a similar picture (graph 14): Brazilian firms invest less in innovation than OECD economies, with the gap being particularly large for R&D investment. While manufacturing firms in Brazil invest 2.8 percent of their sales in such activities, firms in the United States dedicate 3.8 percent of their sales to innovation and firms in Germany invest 5.2 percent; across OECD countries, more than two thirds of this investment is on R&D activities.[9]

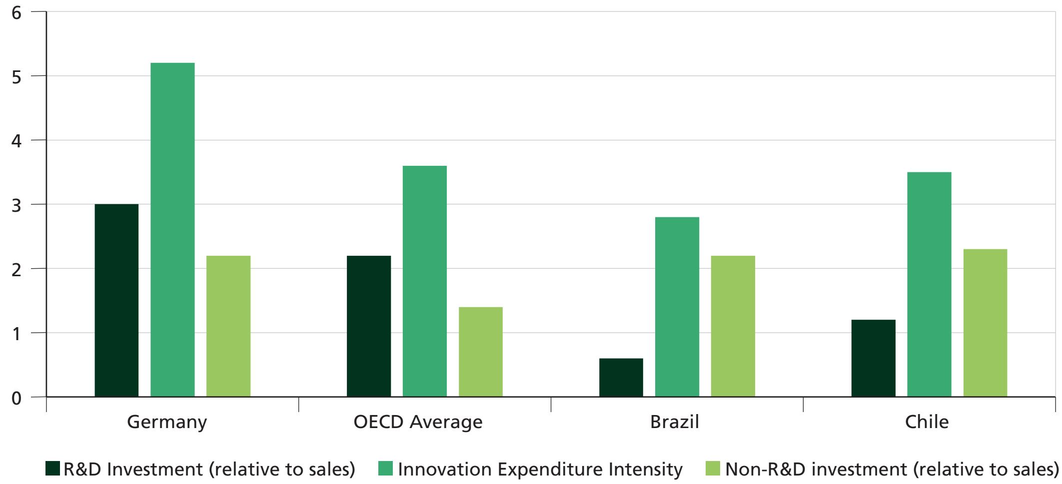
GRAPH 13
Investment in intangibles, selected countries (2012)
(% of GDP and type of objective)



Source: Dutz et al. (2012).

9. According to the Oslo Manual (OECD, 2005), innovation expenditures include R&D and non-R&D investments. The latter include expenditures related to the commercialization of innovations such as machinery and equipment, training, marketing and distribution, technology and know-how licensing, software and hardware and other ICT investment

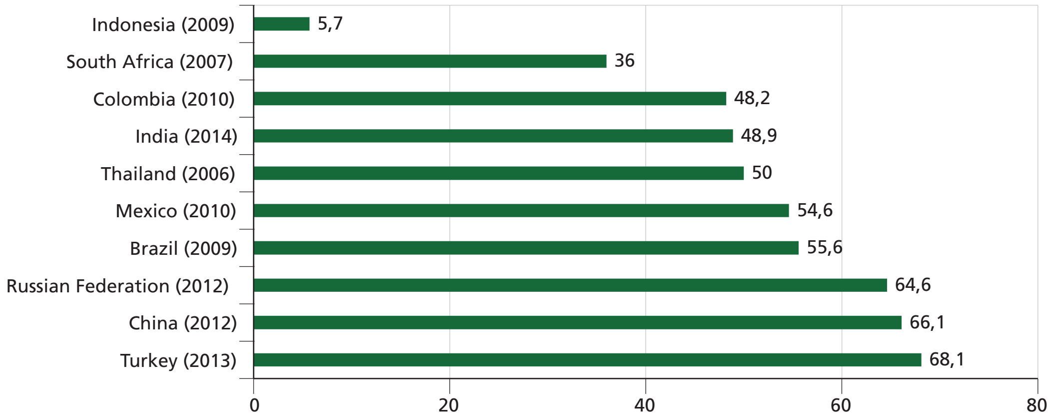
GRAPH 14
Investment in R&D and non-R&D innovation activities, selected countries
(% of sales and type of investment)



Sources: Innovation Surveys for each country: Brazil: 2009-2011 Chile: 2011-2012 and data for OECD countries are from OECD (2009). Indicators refer to manufacturing.

The rates of ICT adoption by Brazilian companies are lower than the rates of other leading emerging countries such as Russia, China or Turkey. While 56 percent of manufacturing companies in Brazil report to have their own website and 84 percent of firms use e-mail to interact with clients and suppliers, the comparable figures are 70 percent and 89 percent in Turkey, and 66 percent and 85 percent in China (graphs 15 and 16). And having a website or using e-mail are only basic forms of ICT adoption, that typically only mark the start of more sophisticated business use. This technology adoption lag is a missed source of productivity gains for all firms in Brazil. The adoption of ICT helps firms to become more efficient by a variety of means including automation of production, improved logistic supply chain organization, and improved business management through cloud platform solutions. Moreover, technology adoption policies for both ICT and management skills upgrading should go hand in hand with other innovation enablers such as broader human capital upgrading and organizational change. The gains that ICT could generate are contingent on parallel investment in these complementary capacities. Returns to productivity are particularly high when firms undertake simultaneous investments in improving organizational structures, process innovation and firm-specific training. More generally, the level of ICT capital intensity (in firms and regions) and its returns on productivity are encouraged by the quality of infrastructure overall (e.g. power infrastructure) and discouraged by strict labor market regulations.[10]

GRAPH 15
Firms having their own website, selected countries, various year
(In %)



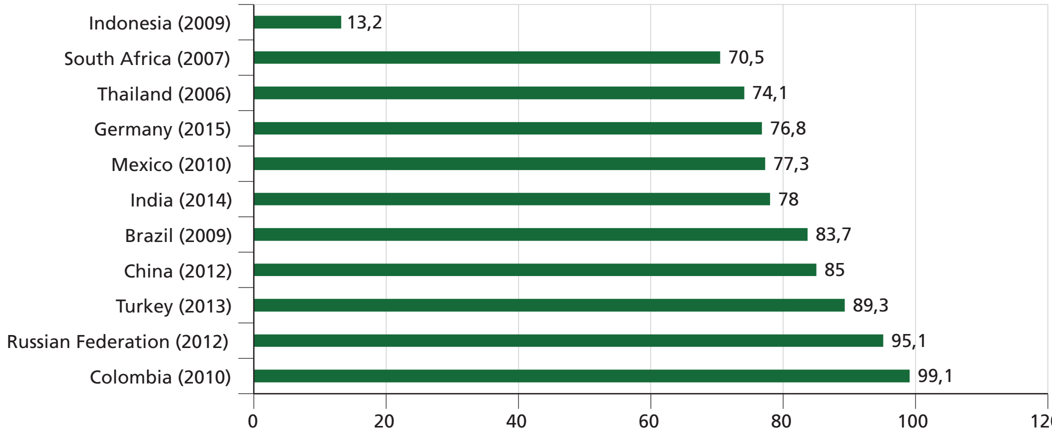
Source: Enterprise Surveys (World Bank).Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012. Indicators refer to Manufacturing industry. Available at: <https://goo.gl/myIVfl>.

In addition, in Brazil, as in many other countries, the adoption of productive ICT (other than internet) investments appears strongly associated to firm size. As size increases, the propensity of firms to adopt ICT expands. For instance, this is the case for the use of local networks (LAN) or software for integral management: this technology adoption reaches above 80 percent of firms in the largest size group of firms (above 500 employees) (graph 17). At the opposite end of the spectrum, micro and small companies report about half the intensity of large firms in the use of local networks (LAN) and about a quarter the propensity of large firms to have productive ICT technologies such as software for integral management.[11]

10. See for instance Commander, Harrison, and Menezes-Filho (2011). In line with some of the evidence from developed countries, they found very high returns to ICT for firms in manufacturing industries in both India and Brazil. Higher returns are concentrated in firms that undertake simultaneous investments in flattening organizational structures.

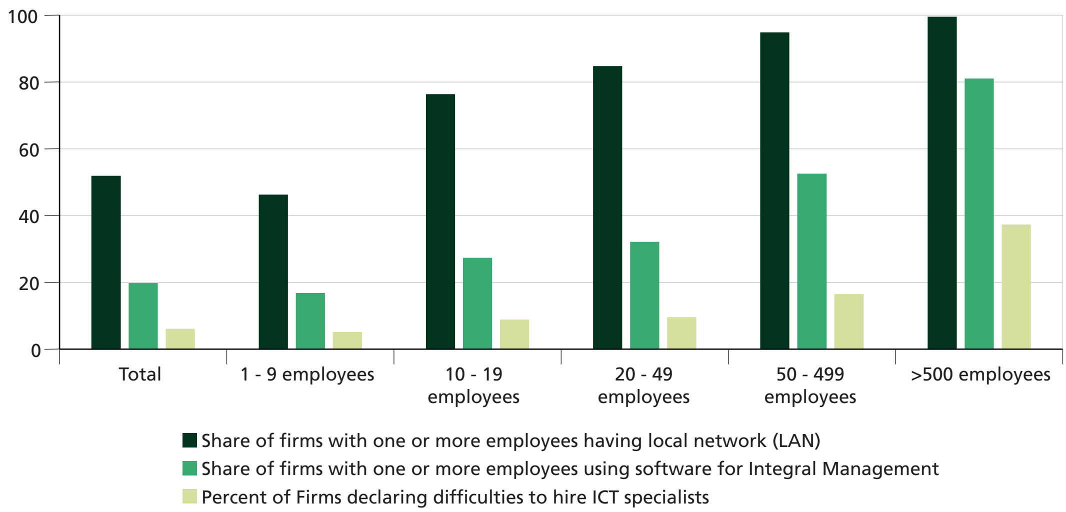
11. Whilst about the totality of large firms (above 500 employees) and 95 percent of firms with 50-499 employees have LAN, this figure is less than 50 percent in firms with 1-9 employees. Likewise, only 17 percent of micro firms (with between 1-9 employees) and 27 percent of small firms (with 10-19 employees) have adopted some kind of software for integral management whereas in firms with above 50 employees (and less than 500) about fifty percent of companies report this type of ICT (IBGE, *Pesquisa sobre o Uso das Tecnologias de Informação e Comunicação nas Empresas,* 2010).

GRAPH 16
Firms using email to interact with clients/suppliers, selected countries, various years
(In %)



Source: Enterprise Surveys (World Bank).Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012. Indicators refer to Manufacturing industry. Available at: <https://goo.gl/jiK4Hl>.

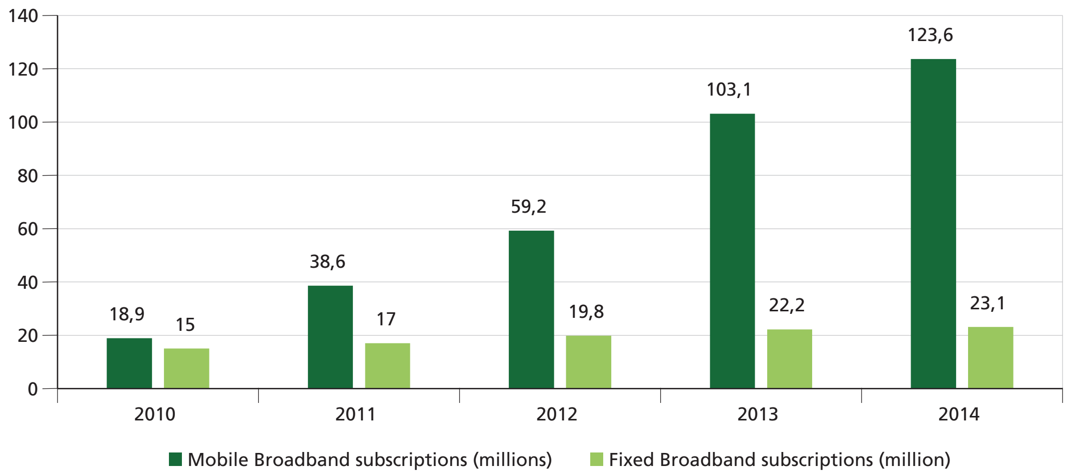
GRAPH 17
ICT adoption by Brazilian firms by firm size (all sectors of the economy) (2010)
(In %)



Source: IBGE. Pesquisa sobre o Uso das Tecnologias de Informação e Comunicação nas Empresas, 2010. Indicators are economy-wide level indicators. Available at: <https://goo.gl/qFlAvR>.

At the same time, Brazil has experienced a rapid increase in mobile communication services in recent years (OECD, 2015a). From 2010 to 2014, Brazil has seen an increase of 79 percent in fixed broadband subscriptions, from 12.9 million to 23.1 subscriptions (graph 18). Mobile broadband access has increased 825 percent in the same period, reaching 123.6 million subscriptions, and the proportion of active users (individuals who have used the Internet on their mobile phone in the last three months) went from 15 percent in 2011 to 31.4 percent in 2013, with a further acceleration in 2014 (Anatel, 2014).

GRAPH 18
Broadband subscriptions in Brazil (2010-2014)
(In millions)



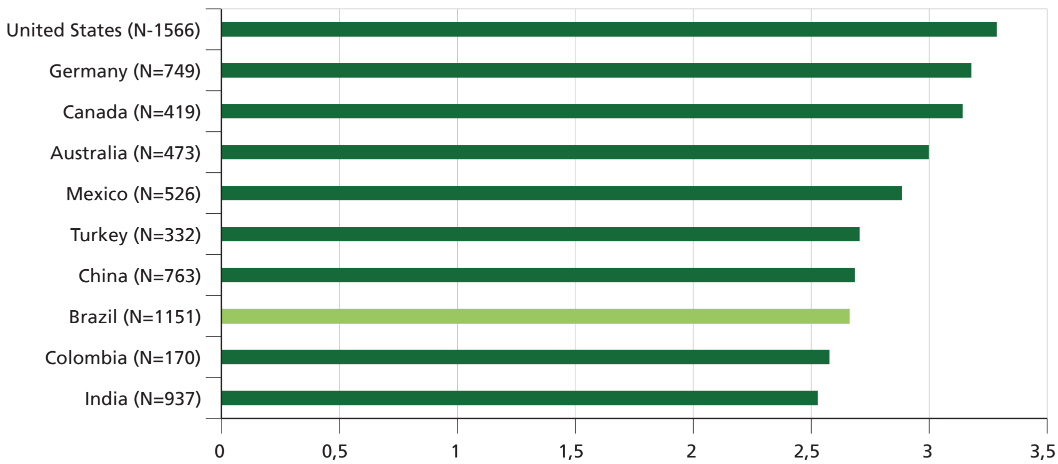
Sources: Anatel (2014).

This rapid growth in the use and access of ICTs is an indication of broader changes in the Brazilian economy and society. Being avid technology consumers, Brazilians embraced digital media rapidly and engaged in social media platforms intensely. This has contributed to the rapid growth in the use of ICTs. As a whole, the ICT sector is in an ascending curve and has shown resilience throughout the international economic crisis, supported by growing domestic demand. The challenge remains to use this social trend for stronger economic growth and innovation.

In terms of managerial skills, Brazil not only lags behind Mexico, Poland, Chile, China and Turkey but has a fatter tail of poorly-run firms than China. Averages of managerial technologies adoption across firms by country are displayed in graph 19 (Bloom et al., 2014). Adopting better management practices is causally linked to productivity improvements and increased employment and incomes over time. Estimates suggest that around a quarter to a third of cross-country and within-country TFP gaps appear to be management related.

Several factors are important in influencing the adoption of better management practices as a key technological driver of business productivity improvements. First, product market competition is critical in increasing aggregate management quality, by thinning the ranks of the badly-managed firms and incentivizing the rest to improve. Regulatory barriers to entry, protection of inefficient incumbents, and vigorous competition policies appear to promote strong management practices, while tax incentives to protect family firms, onerous regulations to slow resource reallocation, and barriers to skill acquisition tend to weaken them. Second, the human capital of managers also plays a role, measured by the proportions that have college degrees. Finally, managers' lack of information and knowledge about how well their firm is managed and how to upgrade management practices matter as well.

GRAPH 19
Average management score by country, manufacturing



Source: World Management Survey. Available at: <https://goo.gl/5gB4Nd>.

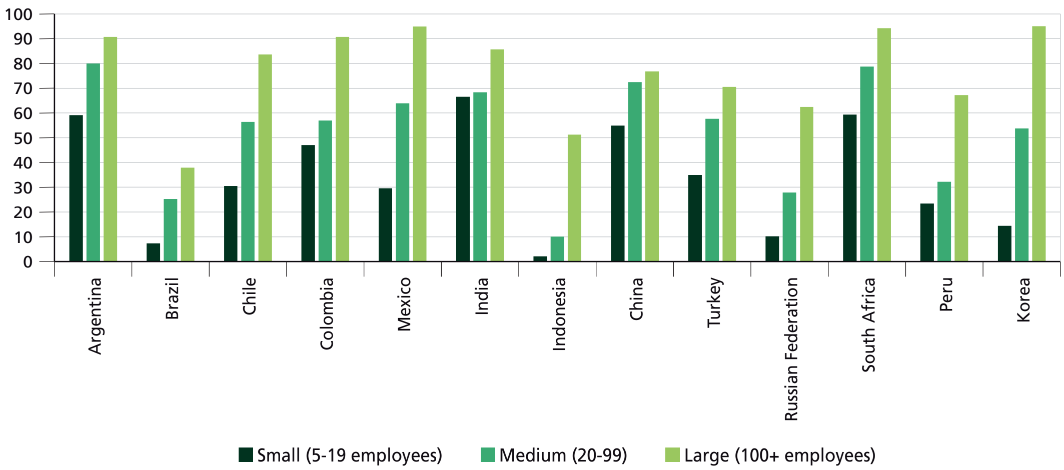
Even in terms of basic managerial practices, Brazilian companies are less engaged than firms in other emerging economies. In graph 20 we report the percent of firms that have annual financial statements reviewed by an external auditor. The rate of firms reporting such a practice is dramatically lower than most other reported countries, and this tendency occurs at all levels of firm size. As with other indicators, the firm propensity to adopt better managerial practices is also substantially and positively related to firm size.

Brazilian firms also seem less likely on average to adopt international quality standards, as reflected in their weaker propensity to adopt ISO international quality certification (graph 21). Alleviating asymmetric information failures – which signals to external parties that the firm is a high-performer on quality management issues – facilitates the firm's integration into global value chains (GVCs) and exporting.[12,13] Although ISO certification is mainly procedural in nature, it is increasingly seen as a requirement for firms supplying goods and services in high quality markets, and is therefore likely to reflect an emphasis on quality in production.

GRAPH 20

Firms having annual financial statements reviewed by external auditor, selected countries, various years

(In %)

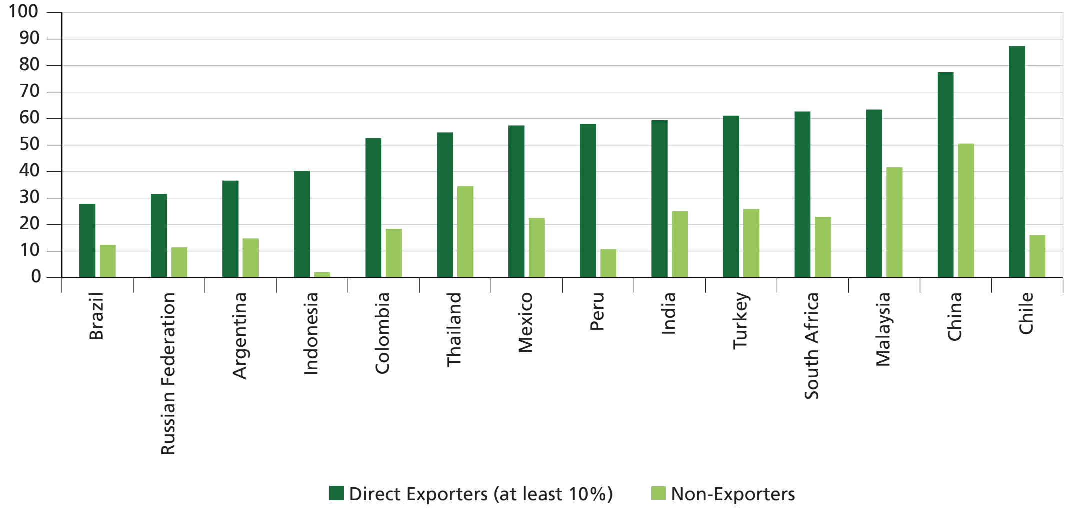


Source: World Bank Enterprises Survey, online database. Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012. Available at: <http://www.enterprisesurveys.org/>.

12. A number of papers show that ISO 9000 certification is correlated with direct measures of product quality (e.g. Brown et al., 1998; Withers and Ebrahimpour, 2000). Goedhuys and Sleuwaegen (2013) show that international standards certified (ISC) firms are more prone to export and export at a larger scale. Results are robust to controls for firm heterogeneity in productivity and skill intensity of the firm.

13. Terlaak and King (2006).

GRAPH 21
Manufacturing firms with international quality certification by exporting status, selected countries, various years
(In %)

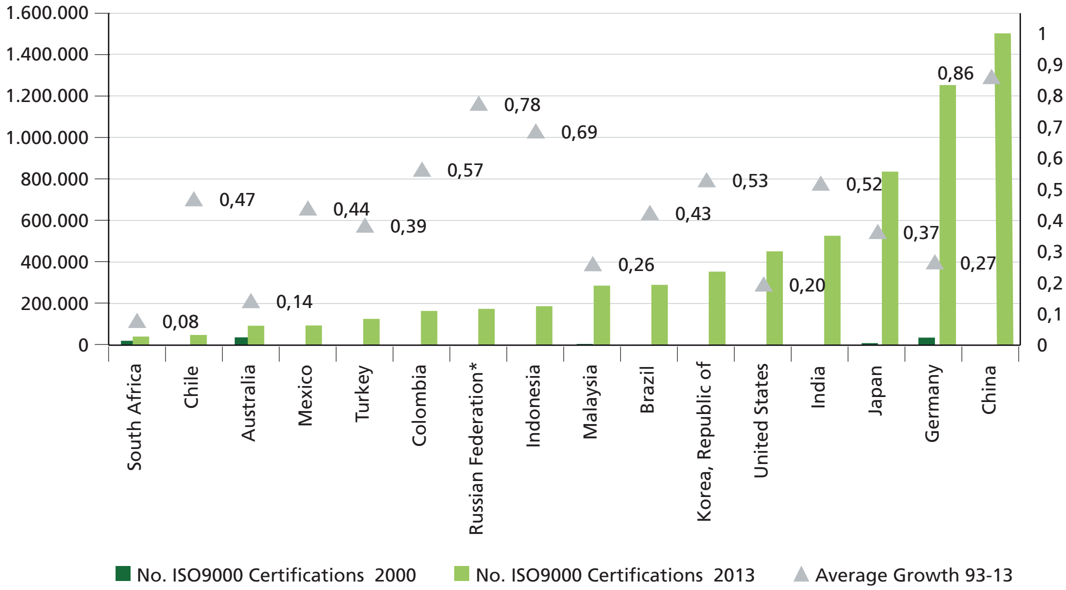


Source: World Bank Enterprises Survey, online database. Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012. Available at: <http://www.enterprisesurveys.org/>.

In Brazil, only 26 percent of manufacturing firms have an international recognized quality certification while the corresponding figure for China is 53 percent. Firms that export are more prone to have international quality certifications than non-exporting firms (graph 21): on average the share of firms with international certification is twice as large as for non-exporting firms. In spite of a dramatic upsurge in international quality certification (ISO-9000) in emerging countries, Brazilian firms have been slower than peers in India, Korea or China in adopting ISO-9000.[14] Adjusted by the size of manufacturing in each economy (graph 22), Brazil displays numbers of international ISO-9000 certifications similar to Malaysia and slightly higher than Indonesia, but half the figures reported by Japan, a third of Germany, and a fourth of China.

14. In Brazil, the average annual growth in the number of certifications registered during the last decade (1993-2013) was 43 percent whereas in China, Russia or Indonesia the number of ISO-9000 certificates grew at an average annual rate far beyond 50 percent (86, 78, and 69 percent average growth rate respectively).

GRAPH 22
International certifications ISO-9000 adjusted by the share of manufacturing in GDP and average annual growth rate, selected countries (1993-2013)

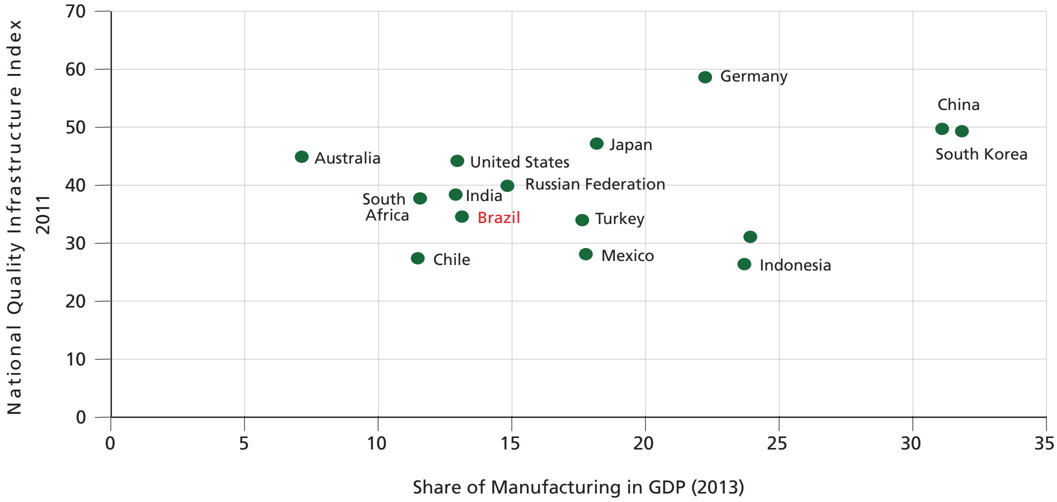


Source: Authors with data from ISO Survey 2013 and World Development Indicators (WDI). Available at: <https://goo.gl/g8lClB> and <https://goo.gl/GZ5aZ6>.

Brazilian firms may be dissuaded from adopting international quality standards because of reasons on both demand and supply sides. On the demand side, local firms may face less competition than that of global firms. On the supply side, firms may have less-developed national quality infrastructure. Brazil ranks 30th out of 53 countries in the Quality Infrastructure Index, adjusted by GDP. Russia, India and South Africa rank 24th, 25th and 26th respectively, and South Korea and China are far better with the 14th and 15th positions. These services include metrology and standardization, accreditation and conformity assessment (inspection, testing and certification). Each of these components is important for the production and development of national and global markets, consumer protection and the attraction of FDI. National quality infrastructure is also crucial to industry development, such as the manufacturing industry (see graph 23).

The lack of developed services in Brazil suggests that public and private providers of quality services are not sufficiently addressing firms' demands, or costs of accessing such services may remain out of reach for SMEs. On the demand side, Brazilian businesses may be less inclined to export to global markets or join GVCs given the importance of their local market, and be consequently less prone to adopt international standards as much as other firms in emerging economies. In this sense, Brazilian companies may be missing opportunities to penetrate and expand in global markets, which would ultimately increase their productivity.

GRAPH 23
Quality infrastructure index (PTB-2011) and the share of manufacturing in GDP, selected countries (2013)

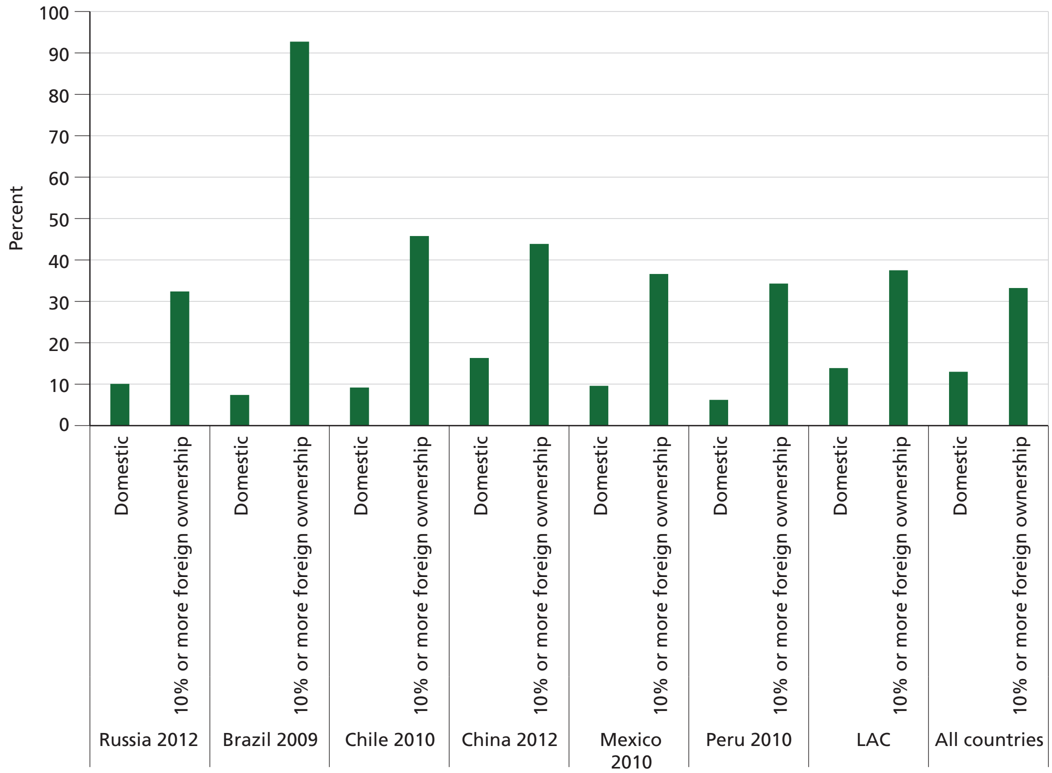


Source: Authors with data from Harmes-Liedtke and Oteiza Di Matteo (2011) and World Development Indicators. Available at: <https://goo.gl/TDpqW7>.

Firms in Brazil also exhibit less use of technology licensing from foreign companies. Only 7 percent of domestic firms in Brazil are engaged in technology licensing whereas firms with this type of technology adoption and learning transaction represent 16 percent of total firms in China, 10 percent in Russia and Mexico, and 13 percent on average for all countries (see graph 24). On average, 14 percent of manufacturing firms across the Latin America and Caribbean region are engaged in this type of technology transfer.

Foreign technology licensing can have important benefits to firms through learning, know-how acquisition, and complementarities with internal technological competencies. For Brazilian firms, a complementary relationship between technology licensing and internal R&D has been found, namely that technology licensing helps explain domestic firms' innovation effort and this effect is only significant when interacting internal R&D with firm licensing history.[15] More generally, technology purchasing is not neutral with regard to its impact on firm innovation and the type of innovation that firms produce. Technology purchasing (both of equipment and disembodied technology trough arms' length contracting), especially of new machinery and equipment, tends to be mostly related to process innovation – the most frequent type of innovation in firms in developing countries; internal R&D is mostly associated with product innovation.

GRAPH 24
Firms with technology licensing from foreign companies per ownership origin, various years
(In %)

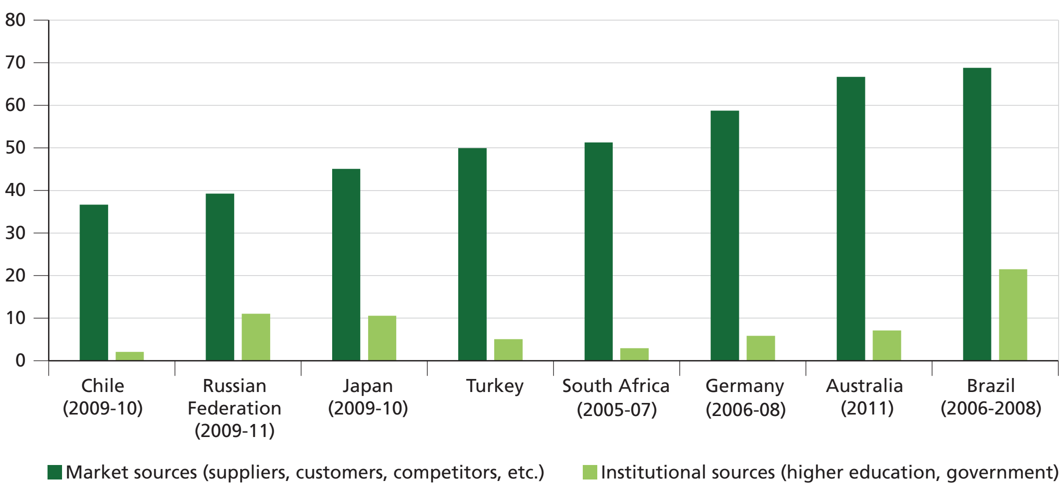


Source: World Bank Enterprises Survey, online database. Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012. Available at: <https://goo.gl/EYgHnZ>.

15. For Brazilian firms, Goedhuys and Veugelers (2012) find that successful process and product innovations occur mostly through "technology buy" (through the purchase of machinery and equipment), either alone or in combination with a "technology make" strategy (R&D). A similar finding is found by Lee (1996) for Korean firms and Alvarez (2001) for Chilean firms. The evidence tends to suggest that exports may underpin the adoption of complementary learning strategies.

Brazilian businesses appear to highly value external sources of knowledge for innovation. Graph 25 conveys a message consistent with the prevalence of catch-up rather than frontier innovation. In line with other economies, Brazilian companies rely much more on the development of innovation from external market sources of information (from suppliers, customers, competitors, etc.) than from institutional sources such as higher education and public-supported basic science. About 70 percent of innovating companies in Brazil claim that market sources of information are highly important for their innovation while less than 50 percent of firms do so in South Africa, Russia and Turkey. What remains unclear is the extent to which Brazilian firms remain constrained in accessing such knowledge, the underlying quality of accessed technologies and the capacity of businesses to make the most productive use of such knowledge.

GRAPH 25
External sources of knowledge for innovation. Product and/or process innovative firms citing source as ''highly important", various years
(In %)



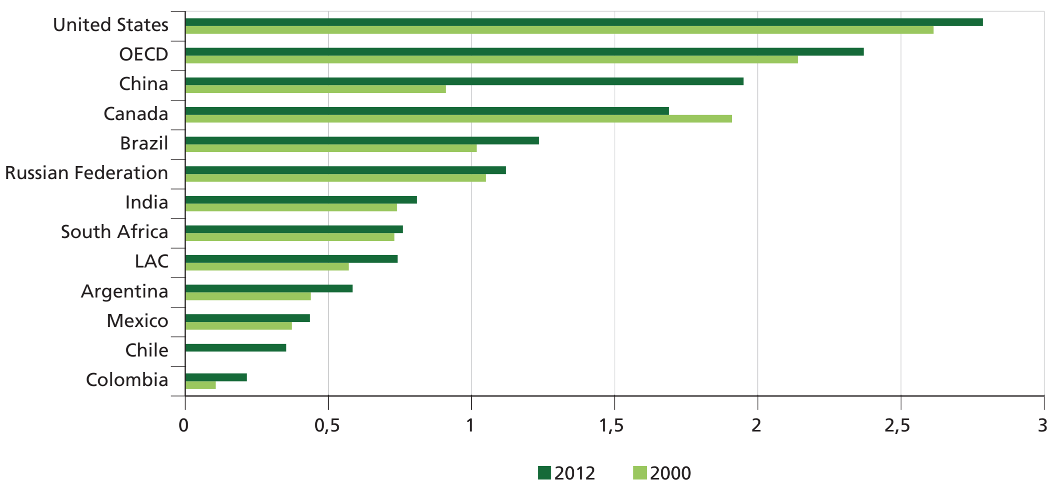
Source: OECD (2013).

2.2.2 Innovation and industry-science collaboration

To remain competitive over the long run, businesses need to develop capabilities for frontier as well as catch-up innovation. Access to and adoption of better existing knowledge is not a sufficient condition for the types of continuous productivity upgrading over time that will eventually require frontier innovation. External technology acquisition and frontier innovation both require a sufficiently developed "absorptive capacity" and enabling "social capabilities".[16] A developed firm absorption capacity eases the process of catch-up by facilitating the search for external technologies, their absorption and their adaptation to local context.[17] This capacity, linked to investments by firms in R&D, enables firms to more productively absorb technologies from outside the firm as well as to develop and commercialize new technologies.

Brazil has been increasing investment in R&D substantially during the last decade, though it lags behind European and OECD countries. Brazilian investment in R&D has increased from 1.01 percent of GDP in 2000 to 1.23 percent in 2012 (graph 26), and has also increased in absolute terms. Nevertheless, a gap remains with respect to developed and other emerging economies, particularly regarding private sector participation in financing and undertaking R&D. In spite of being the top performer in Latin America (representing 60 percent of total R&D investment in the region), investment in R&D in Brazil is roughly half the level of European and OECD countries, who invest on average about 2 percent and 2.5 percent of GDP, respectively (graph 26).

GRAPH 26
R&D as a percent of GDP



Source: OECD (2013), World Bank Development Indicators, World Development Indicators. Available at: <https://goo.gl/3HO2eQ>. RICYT (Red de Indicadores en Ciencia y Tecnología).

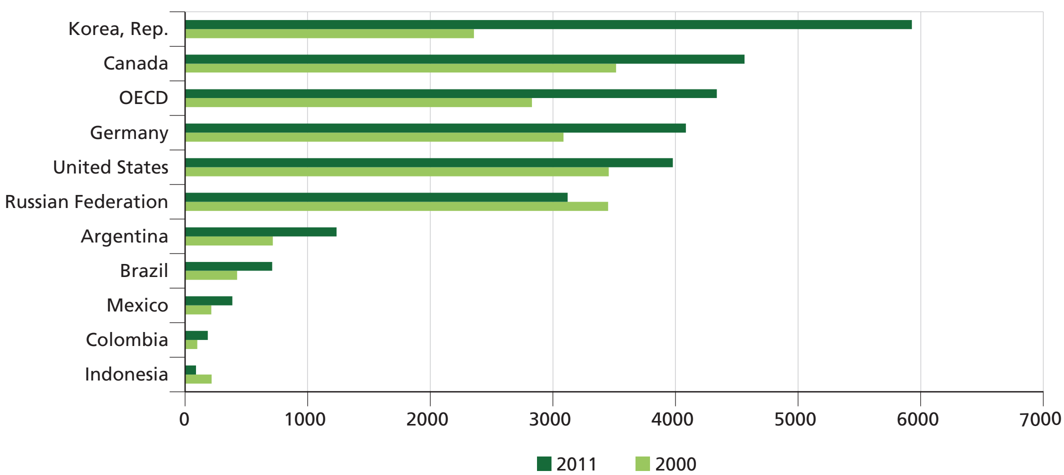
16. On "absorptive capacity", see Rostow (1960); Cohen and Levinthal (1989; 1990) and Griffith et al. (2004). Complementary enablers of catch-up and frontier innovation are "social capabilities" of a country. As defined by Abramovitz (1986), this concerns the efficacy and quality of the regulatory system, common law and related conditions for entrepreneurship and business development, including the financial system and culture for productive development (see also Kim, 1993; Fagerberg and Srholec, 2008).
17. In the terms of Cohen and Levinthal (1989; 1990), having an internal knowledge capacity – as reflected in an internal R&D capacity –, "facilitates search-out of technologies, adoption and adaptation of external technology."

Brazil has increased public research sector inputs and outputs as reflected by R&D financing of the public sector (universities and research & technology organizations), supply of PhDs (formation of advanced human capital), infrastructure for research, and improved scientific performance. Substantial increases in public R&D spending (from 0.52 percent to 0.61 percent of GDP) occurred over 2003-2010 under President Lula, as the government expanded its science and technology (S&T) policy to support both academic research and innovation.

The number of PhD researchers per 100,000 residents more than doubled between 2000 and 2008, expanding from 17 to 40. The share of science and engineering (S&E) PhDs also improved: over the period 2007-2011, Brazil's share of S&E doctorates in total PhDs is now similar to leading economies such as Japan, Germany or South Korea (graph 28). However, most researchers remain working in the public non-business sector. Several deficiencies remain indicating that research excellence standards only concern a handful of institutions.

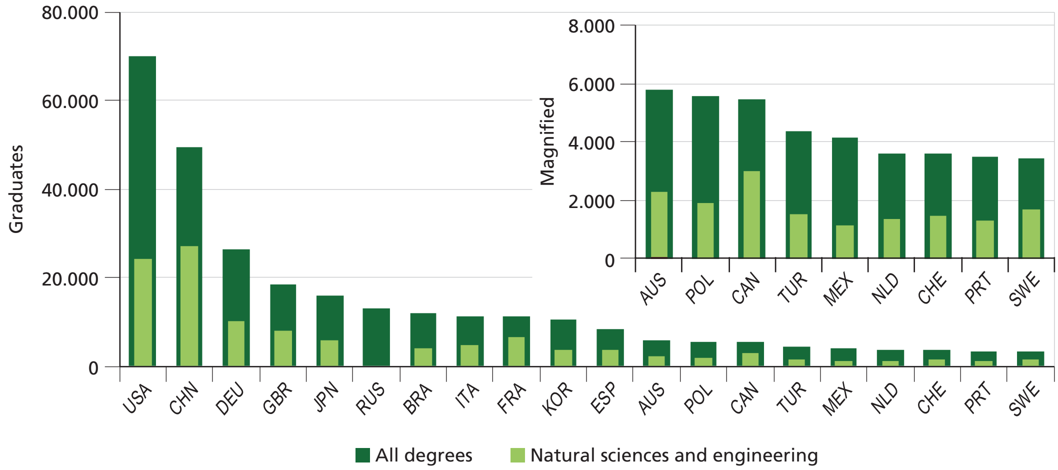
GRAPH 27

Researchers per million people



Source: OECD (2013), World Bank Development Indicators, World Development Indicators. Available at: <https://goo.gl/Ar3qiL>. RICYT (Red de Indicadores en Ciencia y Tecnología).

GRAPH 28
New doctorates in science and engineering (2008-2012)
(% of total doctorate graduates)



Source: OECD (2015b).

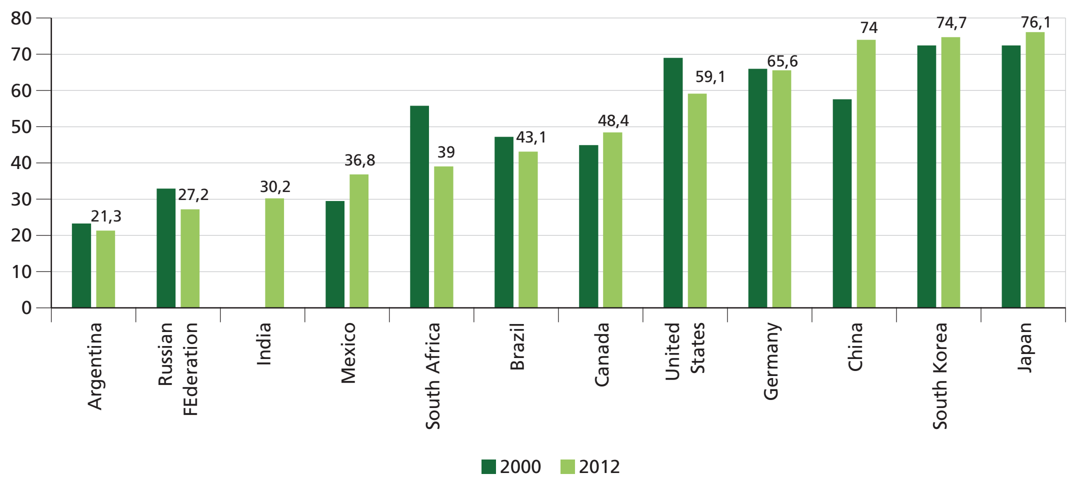
In terms of business investment in R&D, the private sector contributes less than half of total R&D while the OECD average is around 70 percent. The participation of the business sector in the total financing of national R&D has actually decreased between 2000 and 2012 from 47 to 43.1 percent (graph 29) whereas the government share increased from 53 to 56.9 percent. In 2012, R&D financed by the business sector represented 0.53 percent of GDP, a third of the corresponding OECD average at 1.44 percent (OECD, 2015).

Despite increased public investment in S&T and R&D, Brazil suffers from an "innovation shortfall". Even taking into account Brazil's resource-intensive economic structure, the rate of private R&D investment (relative to value added) is substantially lower than OECD and Asian economies.[18] Other countries manage to innovate more even under the counterfactual assumption that they are similarly specialized in natural resource-intensive industries. For instance, assuming that the United Kingdom or the Netherlands shared Brazil's resource-intensive economic structural profile, these countries would spend 90 percent and 41 percent more respectively on innovation. Brazilian businesses could be investing more in innovation even given Brazil's existing accumulation of factors of production.

18. Maloney and Rodriguez Clare (2007) confirm that differences in economic structure are not the problem behind the divergence in business R&D intensity between Brazil and other countries.

Brazil's innovation shortfall is driven by insufficient flexibility in the economy-wide allocation of resources across firms. Brazil's innovation shortfall is not due to a lack of investment in R&D per se. Broader obstacles to productive investment and efficiency prevail in the economy such as barriers to entry and exit of firms, lack of flexibility of markets, and other shortcomings in the broader business environment.[19] Brazil is taxing the accumulation of knowledge, as knowledge is not being translated into economic efficiency and new economic competencies, even taking into account Brazil's relatively high rate of return on education (Maloney and Valência-Caicedo, 2014). A key message for policy makers is to better understand why firms are not doing more to accumulate knowledge assets, rather than continuing to increase public support to investment in R&D.

GRAPH 29
Share of the business sector in the financing of national R&D investment (2000 and 2012)



Source: World Bank Development Indicators. Available at: <https://goo.gl/TBqd6l>. UNESCO, available at: <https://goo.gl/teCySn>. MCTI (Brazil). Available at: <https://goo.gl/4KQbyg>.

Several additional factors have hindered the contribution of public S&T and R&D to economy-wide innovation and productivity. They include: *i*) a disconnect between S&T investments from business needs and demands; *ii*) a too strong focus of researchers on theoretical rather than practical applications; *iii*) regulatory and governance deficiencies that constrain business collaboration; and *iv*) a continued scarcity of engineering and technology specialists.

19. See Klenow and Hsieh (2007); Bergoeing et al. (2006) and Caballero et al. (2004).

First, most of S&T production remains basic research in nature, and incentives in university departments foster isolation rather than interactions with business.

Second, Brazilian research has just started shifting from theoretical to more practical and innovation-oriented fields. This is illustrated by an incipient absorption of researchers in the private sector. In Brazil almost 60 percent of researchers are working in universities while in Germany 65 percent and in the United States 75 percent of researchers work in the private sector. Furthermore, the share of researchers (and support personnel in R&D activities) working in the business sector has decreased substantially over time from 41 percent in 2000 to 20 percent in 2010.[20]

Third, the public research sector is still characterized by regulatory and governance deficiencies that discourage scientists (and institutions) from engaging in technology transfer and collaboration with the private sector. In spite of the important reforms introduced in the legal framework for research organizations with the 2004 Innovation Law, overall incentives for scientists to engage with industry in innovation activities remain weak. For instance, employment rules and criteria for career advancement for researchers are not harmonized across institutions; in several cases, these frameworks fail to recognize the participation by scientists in collaborative activities with industry in researchers' career advancement.

Fourth, a major handicap for firm innovation continues to be the lack of specialists in engineering and technology. Whereas 50 percent of researchers in Japan and about 65 percent in Russia and South Korea are in the fields of engineering and technology, only 20 percent of total researchers belong to engineering and technology (data.uis.unesco, data for 2011). Overall, only 6 percent of researchers in the Brazilian educational system are dedicated to engineering (Pintec, 2011). A general lack of researchers in engineering and technology, and a specific lack of such specialists in business, in turn translates into a weak capacity of firms to interact with and demand appropriate services from public knowledge institutions.

20. Engenhariadata (2014) with data from CGIN (Coordenação-Geral de Indicadores) and from Ascav/Sexec in MCTI. Information sources for business sector are: Pintec (Pesquisa de Inovação Tecnológica) from IBGE, Capes/MEC (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and DGP (Diretório dos Grupos de Pesquisa) from CNPq, special data extraction.

The quality of research and higher education is also a challenge. High-quality research remains largely concentrated in too few universities and regions, and a huge disparity prevails in terms of allocation of inputs and outputs of science and technology (S&T) across regions. Currently, there are no Brazilian universities in the 2014 Shanghai top 100 Higher Education index. The first (and only) Brazilian university to appear in the 101-150 ranking band is the University of São Paulo, with the next universities in the 301-400 ranking band. It is also the only one to appear in the Times Higher Education 2015 World Reputation Rankings, in the 51-60 bands.

Overall, the Brazilian innovation environment and its performance are immature as insufficient collaboration prevails amongst its parts, particularly between research and technology institutions and the private sector. This lack of connection between S&T investments and firm innovation suggests that policies for S&T and innovation have been conceived without sufficient consideration of industry needs. In Brazil, policies have traditionally focused on S&T capacity. In spite of an increased emphasis on industry-science collaboration in more recent years, they remain supply-driven with insufficient involvement of the private sector. As in many other countries, the focus is also still too much on promoting commercialization through patenting and licensing, which are only one channel for commercialization and technology transfer (OECD, 2013a). Other channels, such as public-private collaborative research, student and faculty mobility, contract research, faculty consulting, and student entrepreneurship are also important and also require attention of policy makers. In addition, unfavorable framework conditions such as lack of sufficient market competition and a weak entrepreneurship environment also discourage the emergence of innovators and firms' investments in innovation.

3 CONSTRAINTS TO FIRM INNOVATION

The review just presented indicates that innovation activities by firms – including both catch-up and frontier innovation – appear less developed in Brazil than in peer and OECD economies, including rates of technology adoption.

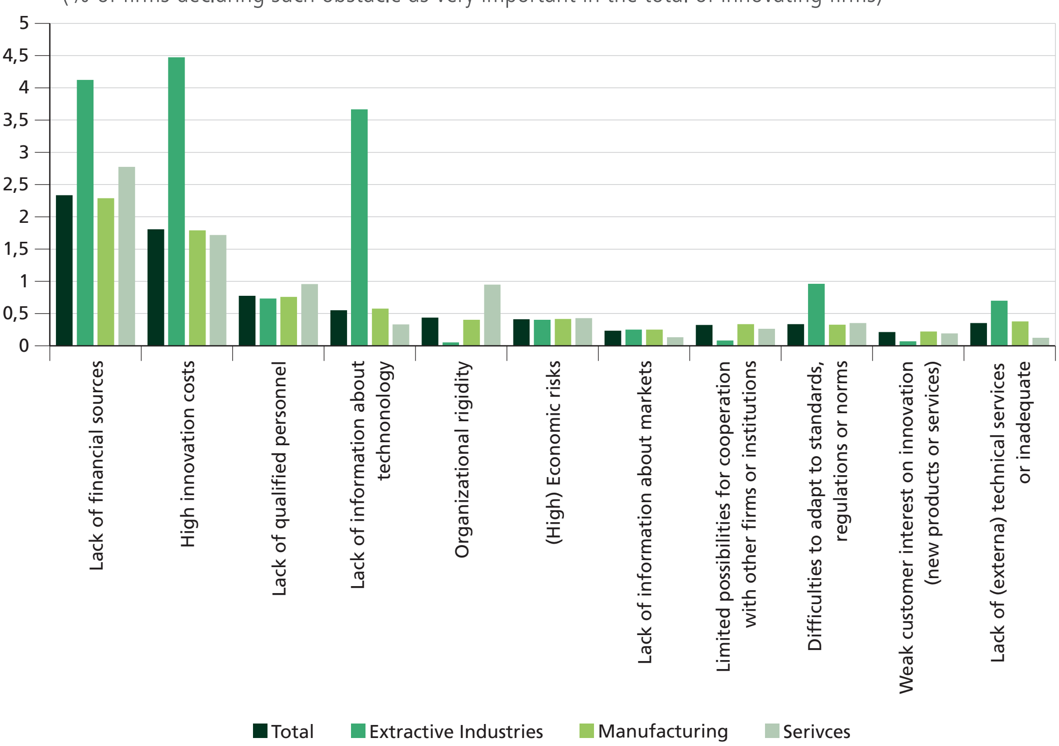
This situation suggests that important constraints prevail on both the demand and supply side discouraging firm innovation. On the demand side, weak market competition, lack of information, or insufficient ability to appropriate returns to knowledge accumulation (e.g. deficient intellectual property protection) can dilute firms' incentives to invest in knowledge and lead them instead to stagnate or at best replicate existing forms of production. On the supply side, deficiencies in human capital formation affecting both workers and managers, lack of mission-oriented policies, and insufficient collaboration and other forms of linkages between private firms and the public sector in the generation and use of knowledge all hinder innovation investment by firms in Brazil.

The main reported obstacles to more investment in innovation activities by these firms are a scarcity of sources of finance, high costs of innovation, and a lack of qualified personnel to undertake innovation activities. According to the Pintec survey (graph 30), these three factors rank the highest across all industries, both in manufacturing and services. In extractive industries, the three most important reported barriers to innovation are again lack of funds and high costs of innovation, but also a lack of technological information for innovation.[21]

GRAPH 30

Obstacles to innovate in Brazilian firms (2011)

(% of firms declaring such obstacle as very important in the total of innovating firms)



Source: Pintec/IBGE. Available at: <https://goo.gl/IXeOGm>.

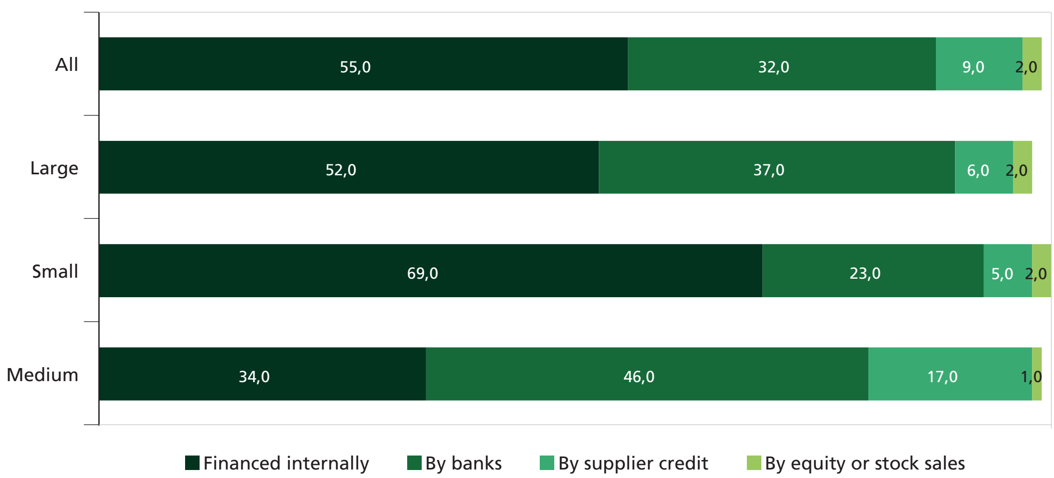
21. When interpreting such self-reported constraints, it should be kept in mind that businesses, like all individuals, have a propensity to report on easily-identifiable external-to-the-firm obstacles, and a difficulty in reporting on what they don't know, with problems such as "I'm not a good manager" or "I would be pressured to more actively seek new markets and customers under a tougher competition and exit threat" typically not asked and not likely to be top answers even if asked.

3.1 Financial constraints

Firms in Brazil report that scarcity of finance is one of the main obstacles to investing in innovation activities. Financial constraints reportedly restrain the ability of domestically owned firms to innovate and export and hence to catch-up to the technological frontier. This factor ranks the highest in all industries, including in manufacturing and services and especially in extractive industries (graph 30).

Financial constraints appear to be particularly detrimental for small or young firms. Evidence also indicates that the intensity of financial constraints varies across industries, and is especially high in services industries – where tangible collateral is often absent.[22] Furthermore, this negative effect is amplified as financial constraints force export and innovation activities to become substitutes although they are generally natural complements[23]. The difficulties in accessing finance for innovation include its high uncertainty and the appropriable nature of ideas (exacerbated by weak intellectual property protection).

GRAPH 31
Brazil: share of investments financed by various sources



Source: World Bank Enterprise Survey. Available at: <https://goo.gl/hf6ZV2>.

22. Evidence on these facts have been reported by Gorodnichenko and Schnitzer (2013) for firms in 27 transition economies and by Alvarez and Crespi (2012) for Chilean companies.
23. For Brazilian firms, Crisostomo et al*.* (2015) provide evidence of the importance of financial constraints for innovation investment in Brazilian companies. They used a panel dataset of 206 Brazilian non-financial firms. Accordingly, innovation of Brazilian firms is adversely affected by leverage and also depends on internally generated funds.

Access to finance constraints have resulted in investments by Brazilian companies being financed with own funds, primarily for small businesses. About 70 percent of investments by small firms are financed internally (23 percent by banks), compared to 34 percent of investments of medium firms (46 percent by banks), and 52 percent of investments of large firms (37 percent by banks) (graph 31).

A range of factors affect access to finance for SMEs in Brazil, including an outdated legal framework for secured transactions and the absence of a unified movable assets registry. In a high interest environment, interest rates for smaller businesses are even higher. Brazil ranks 89th in the Doing Business Getting Credit Indicator for 2015. And Brazil has a score of 2 out of 12 in the strength of legal rights index, compared to a LAC average of 5 and OECD average of 6.[24]

The legal framework for secured transactions has not been modernized, and there is no unified electronic movable collateral registry. Issues with regard to collateral execution contribute to raising the cost of credit. In addition, factors such as informality and SMEs' limited business management and capacity issues have increased credit risk for banks.

Although Brazil has a good regulatory framework and some tax benefits, private equity still has a long way to go in comparison to worldwide leaders such as the United States.[25] The government has a reduced transaction tax for PE investors, which has helped foster investment. In June 2014, the government provided capital gains tax exemption for investors in middle market companies. In 2014, private equity penetration (PE investment as a ratio of GDP) in Brazil was 0.12 percent as of 2014 – low compared to PE leaders such as Israel (1.64 percent), the United States (1.23 percent), the United Kingdom (0.81 percent); but in line with comparable emerging markets such as India (0.19 percent); China (0.15 percent); and South Korea (0.18 percent). Assets under management held by PE funds in Brazil amounted to $ 43bn at the end of 2013.[26]

24. The index measures the level of protection of the rights of borrowers and creditors as measured by laws and regulations.
25. The Brazilian regulator for PE and VC (Venture Capital) is the Brazilian Security Exchange Commission (CVM), which authorizes the funds and their fund managers through licensing. Investors into this asset class must be qualified investors such as institutional investors. The typical funds structure used is the Fundos de Investimento em Participaceoes (FIP) – a closed end, tax-transparent investment fund, registered with the CVM that can invest in the equity of unlisted companies.
26. Insead-PwC Study on Private Equity in Brazil.

While Brazil has a more developed PE/VC ecosystem than many developing countries, it also displays some characteristics common to other developing countries. For instance, growth capital still tends to be the dominant form of PE. Brazilian businesses are often family-owned, which has traditionally resulted in a reluctance to cede control and an increasing trend for PE investors to take minority stakes rather than assume buy-out positions. Deal sourcing also occurs through informal networks.

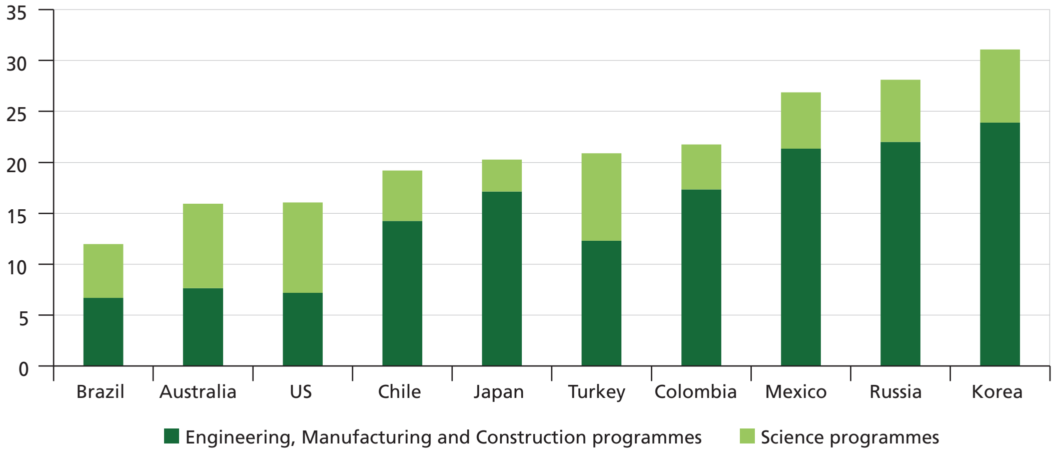
3.2 Human capital

Another major reported bottleneck for firm innovation is Brazil's human capital. In 2009, only 11 percent of the adult population had a tertiary education level (OECD Education Policy Outlook, 2014). Not only the quantity but also the quality of education needs to be reinforced at all levels, with participation of businesses to better reflect their needs. The Brazil PISA science and math scores of 15-year-olds are also among the lowest within the group of reporting countries. Low performance in primary and secondary education leads in turn to low numbers of university graduates in S&T. At the level of tertiary graduates, the dearth of S&T university graduates (as compared to the supply of graduates in social sciences and management) is an important handicap for firms to engage in innovation activities.

Although substantial growth has been achieved in the last 10 years, Brazil still lags behind in engineering education compared to developed economies. Graph 32 illustrates the share of graduates in engineering and science (in total university graduates) for various countries in 2012. In Brazil, the share of graduates in engineering and technology represented only 6.7 percent of total university graduates whereas in Russia and Korea more than 20 percent of university graduates come from engineering-related fields. This situation also has major implications for the capacity of Brazilian firms to transform results from basic research into new products, processes and services. Historically, the share of engineers in the labor force has played a significant differentiating role in helping economies move to higher income levels.[27]

27. Maloney and Valencia-Caicedo (2014) show that differences in innovative capacity, captured by the density of engineers at the dawn of the Second Industrial Revolution, are important factors explaining present income differences, and, in particular, the poor performance of Latin America relative to North America. This remains the case after controlling for literacy, other higher order human capital, such as lawyers, and demand-side elements that might be confounded with engineering supply.

GRAPH 32
Graduates in engineering (technology, manufacturing and construction) and science, selected countries (2012)
(% of total tertiary)



Source: UNESCO Database. Available at: <http://data.uis.unesco.org/>.
Data for Australia corresponds to 2011.

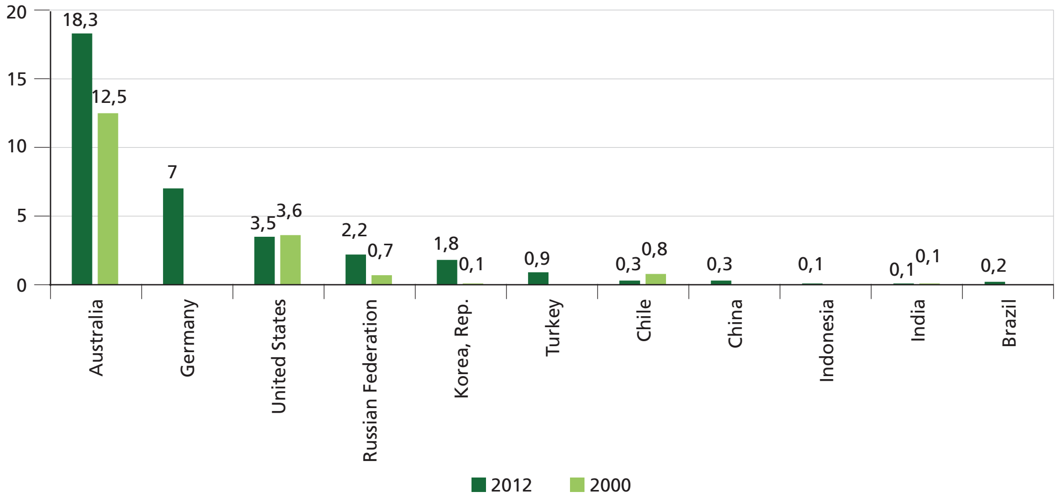
The development of skills in Brazil, especially in S&T, is further hindered by a weaker international mobility of students. Brazil is characterized by low rates of international mobility of both graduate and undergraduate students compared to peer economies (graphs 33 and 34). In an international context where the competition for foreign talent has become more accentuated, countries across the globe are implementing policies to promote the circulation of students and scientists including advanced economies such as European countries (e.g. see programs Erasmus and Marie Curie Fellowships which have been running for more than two decades) and emerging countries such as China and India.[28] The knowledge gain and access to high quality education in globally leading institutions, combined with other advantages such as networking linkages that can be brought back to the home country, have increased in importance. Internationally mobile researchers are associated with a higher impact of their research (Appelt et al., 2015). Brazil has recently taken steps to improve this situation with the launch of the "Scientific Mobility Program" in 2011. New estimates suggest that Brazil has not suffered major outflows of scientists over the past 15 years and has benefited from a small net inflow (graph 35).

Brazil is strengthening efforts to address the issue of skills development and labor qualifications, notably through the Pronatec program and under the umbrella of the "Plan Maior". A key challenge facing Pronatec is to improve partnerships with

28. In 2010, the international student population reached nearly 3.6 million worldwide, increasing by almost 50% over the past six years (Unesco data released in 2012).

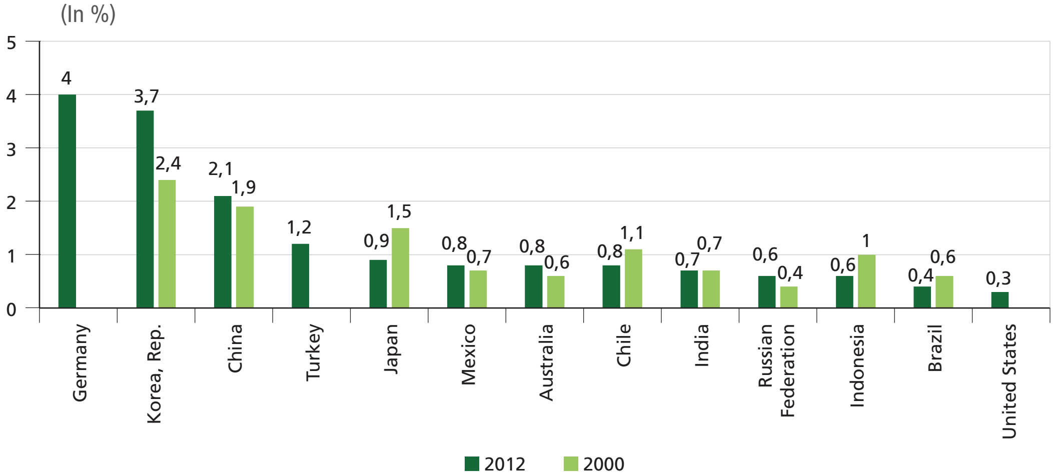
business. Pronatec needs to improve partnerships with the private sector to promote a closer alignment in the supply of TVET (technical and vocational education and training) courses with the quantity and quality of the skills demanded by the labor market. This is a challenge at both the national and subnational levels, given the diversity of local labor market needs, and will require attention to institutional design.

GRAPH 33
Inbound mobility ratio in tertiary education
(In %)



Source: Education Statistics, World Bank 2014. Inbound mobility rate of tertiary education is the number of students from abroad studying in a given country, as a percent of the total tertiary enrollment in that country. Available at: <https://goo.gl/nrE5HD>.

GRAPH 34
Outbound mobility ration in tertiary education
(In %)

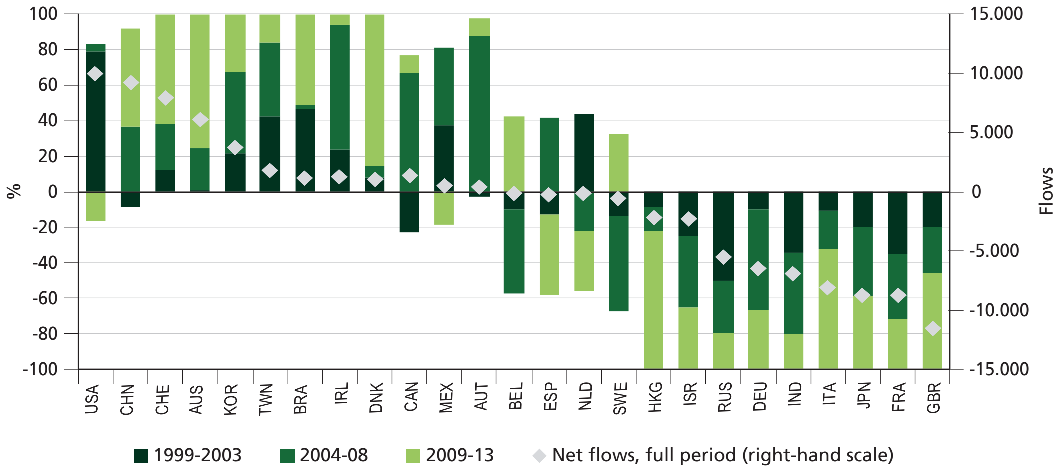


Source: Education Statistics, World Bank 2014. Outbound mobility rate tertiary is the number of students from a given country studying abroad as a percent of the total tertiary enrolment in that country. Available at: <https://goo.gl/GXiwEc>.

GRAPH 35

International net flows of scientific authors, selected economies (1999-2013)

(Difference between annual inflows and outflows, as percentage of cumulative net flows)



Source: OECD calculations based on Scopus Custom Data, Elsevier, version 4.2015. Available at: <http://oe.cd/scientometrics>.

3.3 Regulatory framework

3.3.1 Business regulatory framework

Innovation policies (including science, technology and business innovation policy) will not work or have any impact if framework conditions for innovation are weak and inhibit returns to innovation investments or if businesses encounter difficulties to access competitive sources of knowledge. For governments, the task of supporting business innovation, and more generally, business development and productivity, starts with providing a stable macroeconomic context incentivizing business investment and transactions, instituting appropriate, enforceable and predictable legal frameworks, and removing regulatory, market, and tax-related constraints that inhibit business innovation and firm growth.

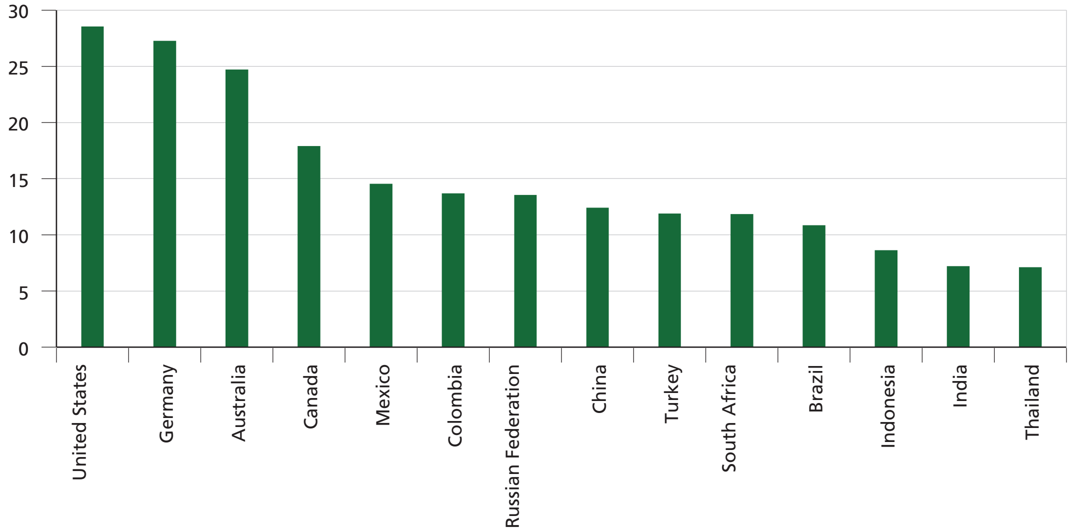
Other framework conditions include: having effective and enforceable competition and anti-trust laws (which seek to restrain both the abuses of large firms with market power through competition law enforcement and anti-competition actions by other parts of government through competition advocacy); innovation-enabling foreign investment and market openness (open trade regimes); enabling start-up regulation; access to credit and capital markets (which are by definition imperfect); competitive national quality systems, intellectual property protection systems in line with international standards; entrepreneurship-friendly bankruptcy laws (enabling firm exit and more rapid reallocation of assets in line with evolving global technologies and demand); and adequate taxation regimes vis-à-vis the nature of the firm (young vs. established, for instance), among others.

In terms of the business regulatory framework (framework conditions) for innovation, Brazil has increasingly detrimental policies given its increasingly closer position to the global technological frontier in areas such as its Intellectual Property Rights (IPR) system, and several regulatory areas especially trade and foreign investment laws that contain legal restrictions dissuading knowledge transactions and access to technology markets, undermining the process of technology learning and the extent of innovation activities. To the extent that weaknesses in Brazil's IPR regime remain unaddressed, learning opportunities will be foregone. This is especially important for access to frontier technologies that are sensitive to IPR such as pharmaceuticals, chemicals and software. Brazil has a lower level of IPR protection than comparable countries such as Mexico, Colombia, Russia, China, Turkey and South Africa (graph 36). According to this index, Brazil's shortcomings include its Law for Internet, with weak protection of copyright online; patent enforcement and resolution mechanisms not being available in pharmaceuticals; patent restoration not being available; and a low rate of membership and ratification of international IPR treaties. In addition, it takes up to eight years to process a patent in Brazil as opposed to two and a half years in Mexico.

Improving the IPR legal framework and functioning is important for innovation and business development, particularly for countries moving up in the development cycle and starting to invest in frontier innovation capacity.[29] As economies develop and acquire valuable knowledge assets, local firms begin to develop a vested interest in building IPR institutions and protecting intellectual creations to foster competitiveness.[30] An effective IPR system is also ancillary in the development and organization of markets by helping consumers scrutinize the quality of products and services and their origins, e.g. signaling quality of a brand is the main attribute of trademarks, origin designations, and geographic indications.

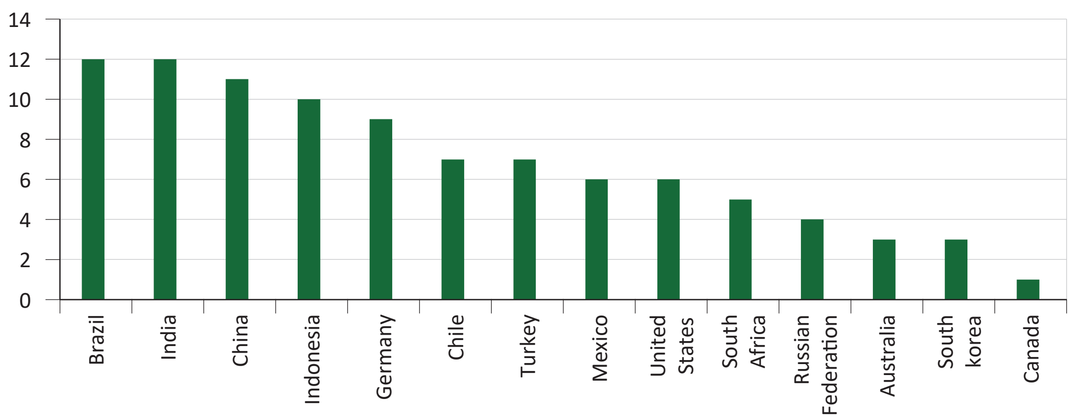
29. For these reasons, IPR are central to competitiveness and business growth particularly in countries which have started to move up in the curve of development (middle-income countries) and intending to move towards higher levels of development.
30. Maskus (2000).

GRAPH 36
International intellectual property index (2014)



Source: International Intellectual Property Index. Available at: <https://goo.gl/6ZPlSW>. [31]

GRAPH 37
Number of procedures to register a new business in 2014



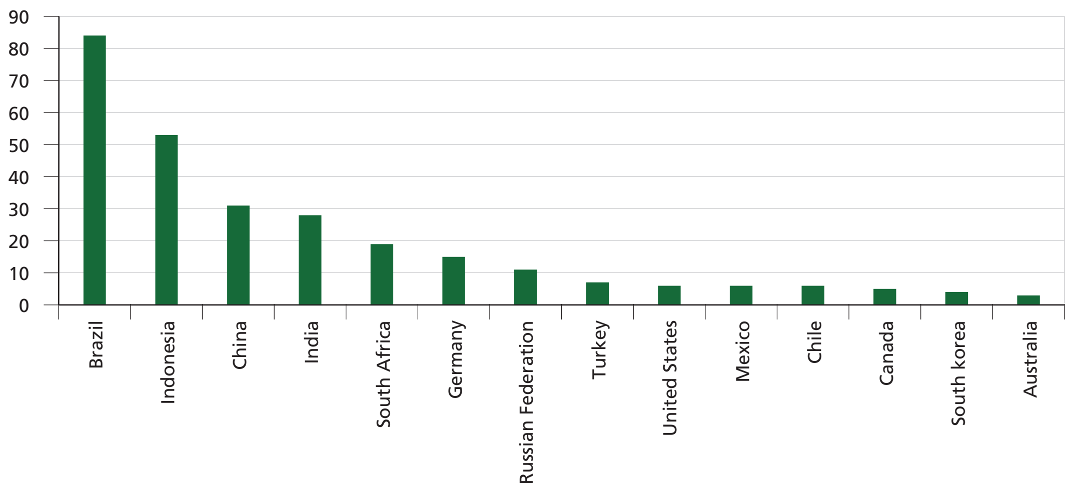
Source: World Development Indicators. Available at: <https://goo.gl/Oa0qPn>.

Brazil trails substantially behind peer economies in several dimensions of the regulatory business environment for firm creation. In 2014, jointly with India,

31. The 2015 GIPC Index maps the IP environment of thirty economies, comprising nearly 80 percent of global gross domestic product (GDP). The GIPC Index consists of thirty indicators divided into six major categories. Each indicator is scored between 0 and 1. The maximum available score for the entire GIPC Index is 30.

the number of procedures to register a new business was the highest among the BRIC economies (graph 37). This number was seven times larger than that of Canada and five times larger than that of South Korea. The time it takes to register a new business was also the longest recorded within the group of countries selected for comparison. It takes more than eighty days to open a new business in Brazil while in the United States, Mexico or Canada it takes less than ten days (graph 38).

GRAPH 38
Number of days to register a new business in 2014



Source: World Development Indicators. Available at: <https://goo.gl/OlJBg6>.

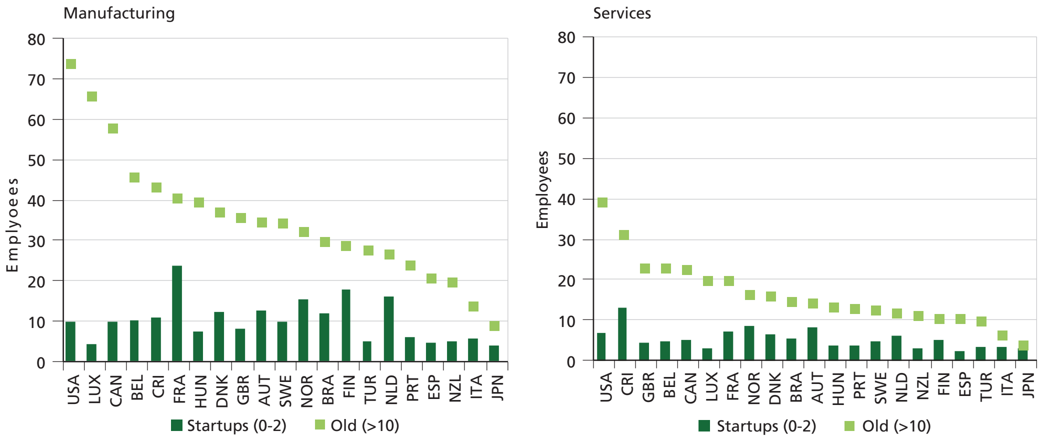
Entry regulations are not the only concern for firm growth, however. Regulatory policies also need to enable the experimentation with new ideas, technologies and business models that underpin the success of innovative firms, be they large or small. Subsidies to incumbents and other policy measures that delay the exit of less productive firms can stifle competition and slow the reallocation of resources from less to more productive firms. Examples include fiscal measures that favor well-established firms – such as R&D tax credits which do not have carry forward provisions.

Young firms are particularly important for innovation and play a key role in employment creation, accounting for over 45 percent of all new jobs created across several countries over the past decade, and an even higher number in Brazil (Criscuolo et al., 2014). Even if only some of these firms reach a large scale, they help drive renewal and creative destruction in the economy and support the growth of new and emerging areas. However, the average young firm does not scale very well in many countries (graph 39), and their small size limits their impact on innovation, the economy and society. Policies which constrain the growth of firms should therefore be assessed with particular care.

Examples include both regulations which only affect firms above a certain size, but also rewards, such as support mechanisms for which only smaller firms are eligible.

GRAPH 39

The average size of start-ups and old firms



Source: Criscuolo, Gal and Menon (2014) and OECD DynEmp Express Database, April 2015. Available at: <https://goo.gl/j2vkY5>.
Note: The figure reports the average size of start-up firms (from 0 to 2 years old) and firms more than 10 years old, over the available years. See source for country-specific details.

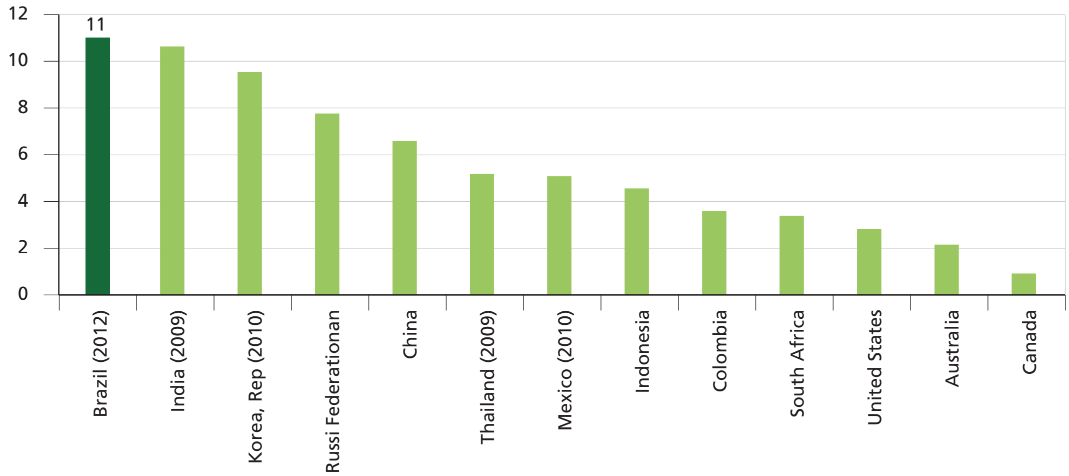
Trade regulation is another policy area with implications for innovation, especially considering that restrictions to trade have expanded in the last years. Despite significant growth in the value of Brazil's trade in goods and services over the past decade, trade openness (exports plus imports of merchandise and services relative to GDP) in Brazil is the lowest in the world and international trade and GVC integration remains limited. To the extent that importing and exporting directly enhance productivity through business learning (global practices) and innovation, limited international integration may be one important explanation of Brazil's productivity challenge and lack of innovation.

Within a global trade environment where tariffs have been considerably reduced, Brazil's bound and applied tariffs remain significant. Brazil's MFN applied tariff rate averaged 13.5% in 2013, the highest rate in comparison to other emerging and advanced economies. In addition Brazil's average bound tariff in the WTO is significantly higher, at 31.4% (World Trade Organization database).[32] Tariffs are not only high on final products, but also on intermediate and capital goods, which are becoming increasingly important in a globalized world. Graphs 40 and 41 show that Brazil has the highest average tariff on both intermediate and capital goods, in comparison to other developing, emerging and advanced benchmark economies.

32. Available at: <https://goo.gl/YBKM9b>.

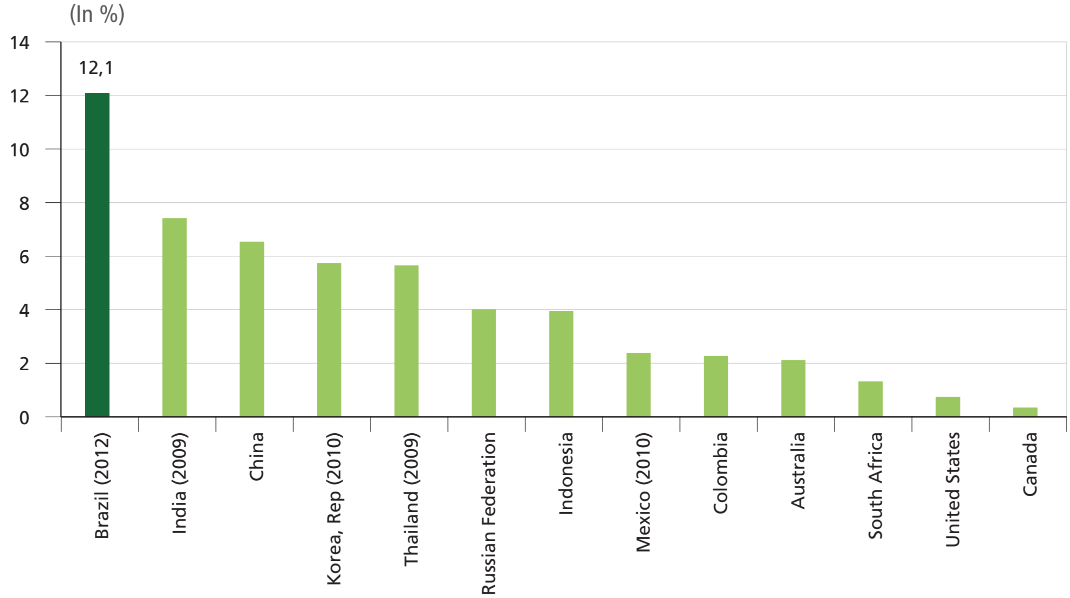
Brazil's tariffs on capital goods averaged 12.1% in 2012, much higher than in India (7.4%), Colombia (2.3%) and the United States (0.8%).

GRAPH 40
Average tariff on intermediate goods (2013)
(In %)



Source: World Bank, WITS.
Note: Years vary based on data availability. Available at: <https://goo.gl/R2ejjQ>.

GRAPH 41
Average tariff on capital goods (2013)
(In %)



Source: World Bank, WITS.
Note: Years vary based on data availability. Available at: <https://goo.gl/F8NlnY>.

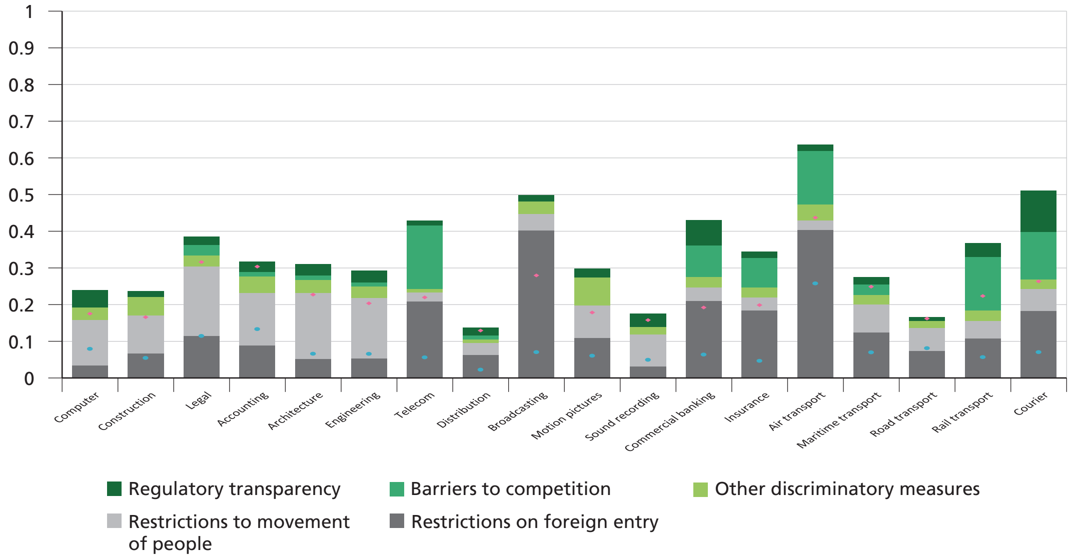
Brazil has also deployed its use of Non-Tariff Measures (NTMs), which in most cases contribute to restrict trade openness as well. Within the large NTM category, Brazil has especially been a proponent of local content requirements (LCRs), which can have harmful effects on productivity. Since NTMs increase the costs of trading products across borders, firms engaged in international trade will typically transfer part of this extra cost to the final price of the product sold in the market. NTMs have been shown to increase domestic prices by an average of 8.7 percent worldwide (Kelleher and Reyes *apud* Malouche et al., 2013). The price-raising effect of NTMs typically restricts access to intermediate products, hurts the competitiveness of affected businesses, and hurts the poorest in the case of imported necessities.[33]

Barriers that affect trade in services are also of growing importance for Brazil's overall trade performance, both for direct trade in services, but also due to the role of services in enabling and creating value for trade in goods.[34] The OECD Services Trade Restrictiveness Index points to several sectors where regulations particularly affect services trade (graph 42). Brazil has a higher than average score on the STRI in all sectors except accounting, a fact explained both by general regulations affecting all sectors and by sector-specific rules. There are thirteen separate administrative procedures required to register a company, and obtaining the required permits and registrations can be lengthy, raising the cost of establishment in all sectors.

Another general regulation provides differential treatment of foreign suppliers under the procurement law. Moreover, limitations on the temporary movement of people affect services providers in all sectors. Brazil imposes a labor market test for all categories of services suppliers, according to which foreign workers can only be hired if no potential Brazilian candidate has the required skills. The managers of a joint-stock company must be resident in Brazil in all sectors.

33. Malouche et al. (2013); UNCTAD (2013); Cadot et al. (2012).
34. Refer to Arbache paper

GRAPH 42
Services trade restrictiveness index for Brazil

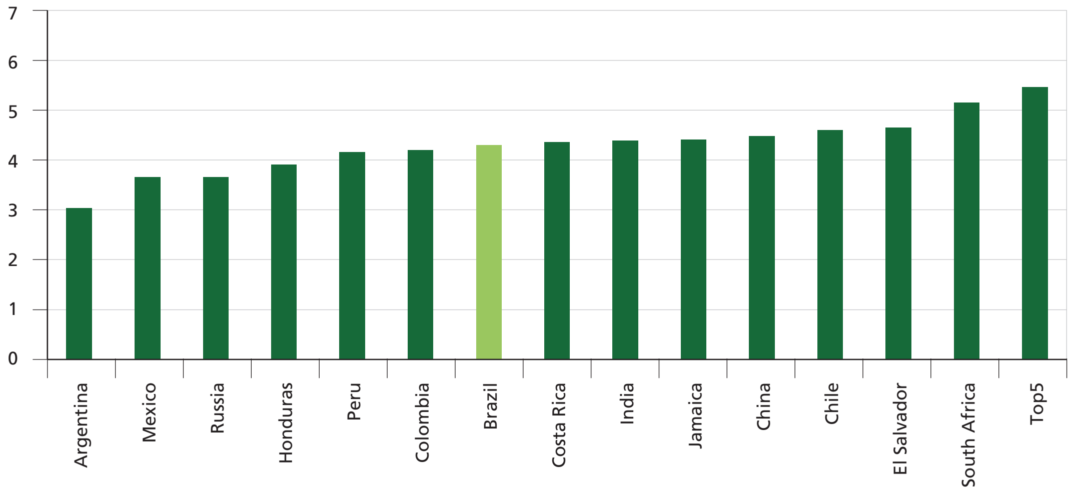


Source: OECD (2014): Services Trade Restrictiveness Index. Available at: <https://goo.gl/n5ipzh>.

Services account for only 14 percent of Brazil's gross exports, but close to 50% in value added terms (OECD, 2015b), indicating that Brazil's exports of goods rely intensively on services inputs. Cost effective state-of-the-art services are therefore of utmost importance for the competiveness of the Brazilian industrial sector. The present contribution of services to exports is, however, lower than average. The STRI points to some regulations that may help explain this relatively low share and can help identify good-practice regulation that can help improve overall productivity and competitiveness.

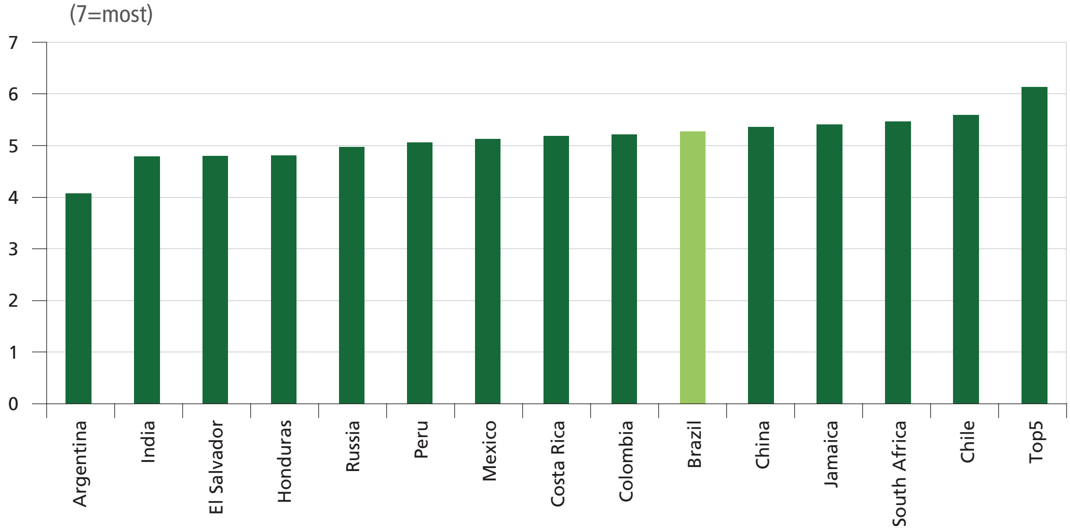
Despite progress, particularly in detecting and deterring cartels, the degree of competition in Brazilian markets is still relatively low when compared to other rapidly growing economies and other countries in the LAC region. Brazil ranks 52nd out of 144 countries regarding the intensity of local competition and 55th in relation to the effectiveness of its anti-monopoly policy (WEF Global Competitiveness Report 2014-2015) (graphs 43 and 44).

GRAPH 43
Effectiveness of anti-monopoly policy (2014-2015)
(7=most)



Source: World Economic Forum - Global Competitiveness Report 2014-2015. Available at: <https://goo.gl/GybnV7>.
Note: Top 5 refer to best performing countries in GCR for each indicator.

GRAPH 44
Intensity of local competition (2014-2015)
(7=most)



Source: World Economic Forum - Global Competitiveness Report 2014-2015. Available at: <https://goo.gl/7zieUY>.
Note: Top 5 refer to best performing countries in GCR for each indicator.

Barriers to entry and rivalry remain the main source of restrictiveness in the Brazilian regulatory framework. According to OECD's Product Market Regulation Database, barriers to entry and rivalry increased from 2008 to 2013 (Koske et al., 2015).

In particular, the license and permits system remains highly restrictive to competition. Aside from the market regulatory constraints in the infrastructure sectors, regulatory barriers in the service sector are also very important, restricting competition more severely now than five years ago. Professional services are notably one of the most restrictive regulatory frameworks when compared to other key sectors evaluated by OECD's PMR indices. In four professions (accountancy, legal, engineering, architecture), membership in a professional organization is compulsory for exercising the profession. Brazil was the only BRICS country where the overall index of product market regulation did not decline between 2008 and 2013 (Koske et al., 2015).

3.2.2 Regulatory framework and governance of research systems

Regulatory and governance deficiencies in the public research sector discourage scientists (and institutions) from engaging in technology transfer and collaboration with the private sector. In spite of the important reforms introduced in the legal framework for research organizations with the 2004 Innovation Law (which was inspired by the Bayh-Dole Act from the United States), incentives for scientists to engage with industry in innovation activities remain weak.

Among others, employment rules and criteria for career advancement for researchers are not fully harmonized across institutions and in several cases these frameworks fail to recognize scientists' participation in collaborative activities with industry in researchers' careers. In addition, as mentioned earlier, a major handicap for firm innovation continues to be the lack of specialists in engineering and technology (Pintec, 2011); this in turn translates into an inability by firms (on the demand side) to interact with public knowledge institutions.

New reforms are under discussion at the Congress with the recent launch of a new Science, Technology and Innovation Legal Code (Law n. 13,243/2016). This code aims to make more effective the collaboration between public institutions and private firms, as well to use the purchasing power of the government to foster innovation. Nevertheless, the use of Public Procurement for Innovation (PPI) and Pre-Commercial Procurement (PCP) are both constrained in the current general Brazilian legal framework.

3.4 Weak collaborative culture

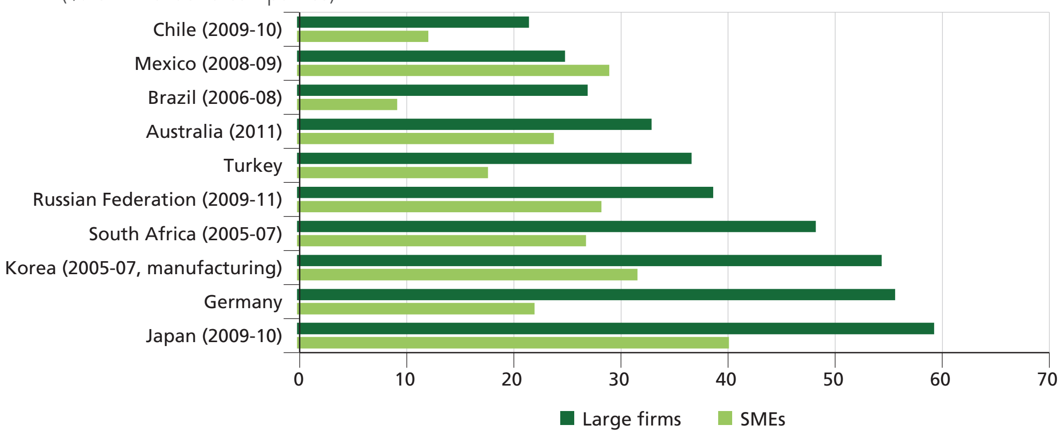
The lack of a cooperative culture in Brazil is a major barrier to innovation and productivity. In spite of valuing external sources of knowledge for innovation, Brazilian businesses appear handicapped by a low level of collaboration with other firms and institutions.

Networks of external collaboration across innovators, apart from the exceptional cases of well-known strategic industries (oil, aerospace and agro-industry), are not sufficiently developed in Brazil relative to comparator and OECD countries (graphs 46 and 47). The propensity to collaborate is much weaker for SMEs (graph 45), with only five percent of innovating firms collaborating with higher education institutes or research organizations compared to 23 percent in large companies.

GRAPH 45

Co-operation in innovation with other firms or institutions by size, various years

(% of innovative companies)

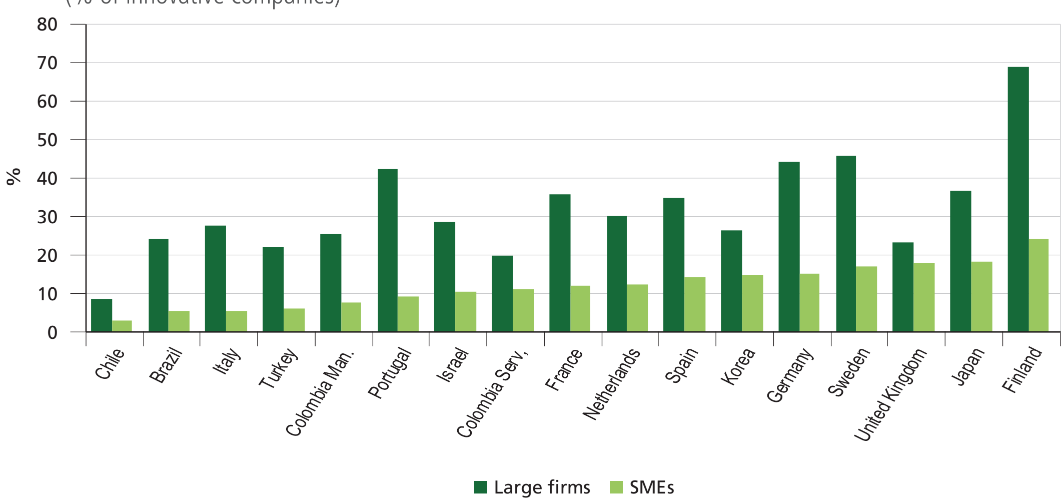


Source: OECD Industry, Science and Technology Scoreboard (2013). Available at: <https://goo.gl/W5Z2I4>.

GRAPH 46

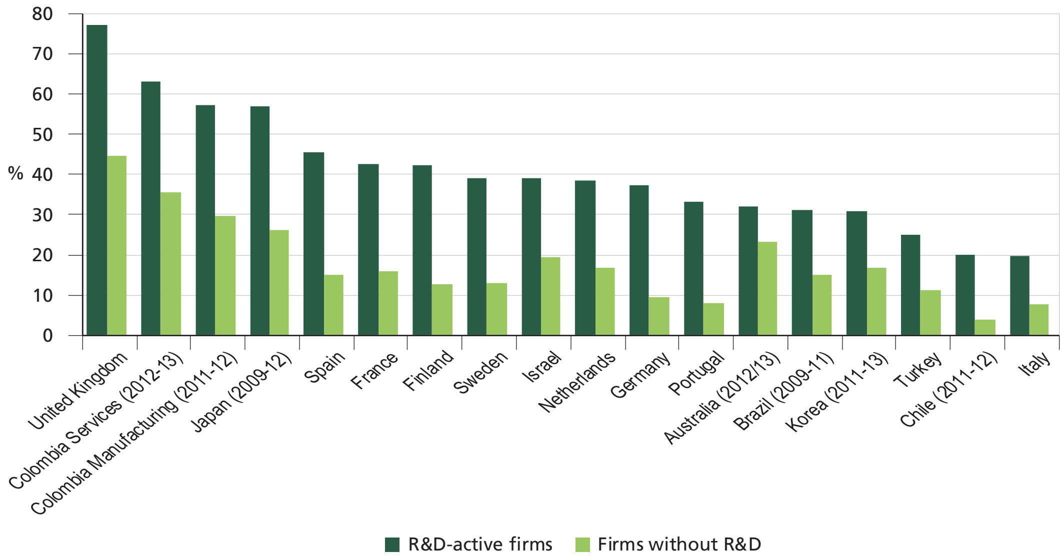
Co-operation in innovation with other higher education or research institutions by firm size (2010-2012)

(% of innovative companies)



Source: OECD Industry, Science and Technology Scoreboard (OECD, 2015b). Available at: <https://goo.gl/WENY7p>.

GRAPH 47
Co-operation in innovation with other firms or institutions by R&D status, various years
(% of innovative companies)



Source: OECD Industry, Science and Technology Scoreboard (OECD, 2015b). Available at: <https://goo.gl/lOj3vR>.

This weak cooperative culture suggests the existence of missed opportunities to jointly learn and innovate. Technologies have become more complex and new products and services demand an increasing range of technological competencies, often dispersed across different firms including global firms and knowledge institutions located abroad. Collaboration in innovation can have important benefits for firms.

Cooperation activities in principle can help businesses access complementary technological resources (such as skill sharing) and reduce costs, and thereby develop economies of scale and scope.[35] Cooperation with other firms, particularly with clients and suppliers, is frequently associated with increased innovation performance and productivity gains.[36] Cooperation with customers appears to boost market acceptance and diffusion of product innovation. Interestingly, in countries where cooperation is relatively high (OECD, 2014), respondents generally rate the obstacles to innovation low, suggesting that either the same barriers to innovation also impede cooperation or that cooperation is an effective tool to overcome barriers and their perceived impact.[37]

35. See Cassiman and Veugelers (2002); Cassiman, Pérez-Castrillo and Veugelers (2002).
36. See Harrison and Freel (2006); Belderbos, Carree and Lokshin (2004).
37. OECD Science, Technology and Industry Outlook (2014).

4 POLICY CHALLENGES AND GAPS

Over the last decade, Brazil has undertaken a number of actions to reinforce its national innovation capacity, ranging from programmatic funding support, support through broader industrial policies, and additional regulatory reforms. In the early 2000s, a series of public policies were implemented, initially with the Sectoral Funds (created in 1999), the Innovation Law (Law n. 10,973, of December 2004) and the "Lei do Bem" (Law n. 11,196, of November 2005).

The Innovation Law provides rules for intellectual property creation and commercialization at public research institutions and facilitates collaboration between universities and private businesses. The law encourages the public and private sectors to share staff, funding, and facilities, and has allowed researchers to work in other institutions to conduct joint projects and request special leave if they decide to become involved with a start-up company. The *Lei do Bem* makes it easier to use indirect tax incentives for private R&D investments (such tax incentives were originally introduced in the 1990s). It also enables funding for firms to hire specialized Masters and PhD level employees.

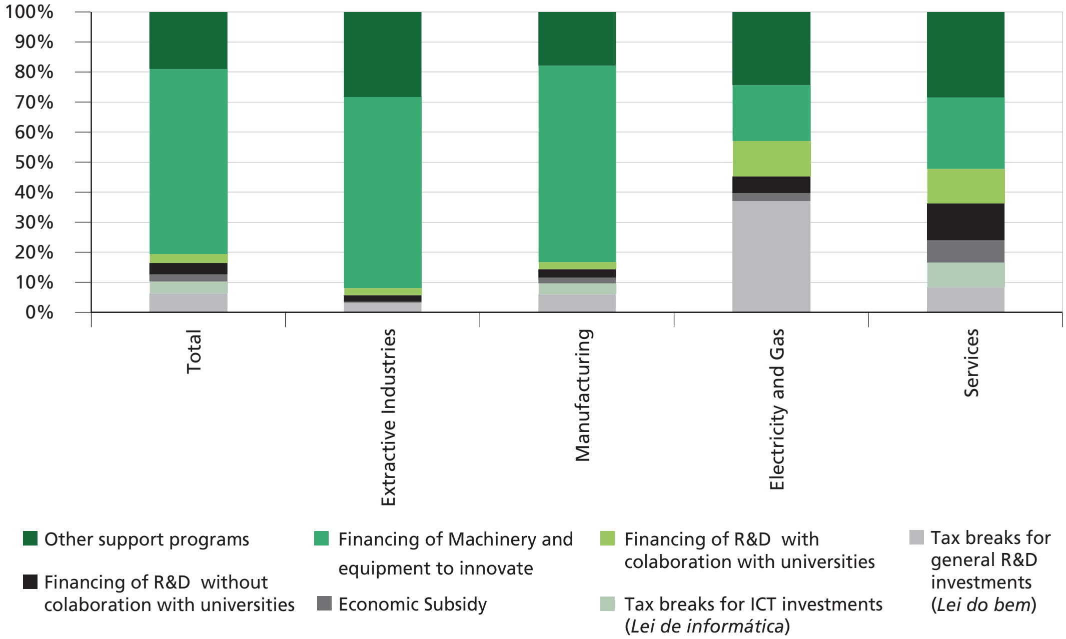
The first industrial policy implemented by the Brazilian Government in 2003 was called Industrial, Innovation and Foreign Trade Policy (PITCE in the Portuguese acronym). The government has launched additional industrial policies, including the Production Development Policy (PDP, 2008), the *Brasil Maior* Plan (in 2010), and the Science, Technology and Innovation Action Plan (PACTI). Although some of these policies have included as one of their stated objectives to foster innovation, innovation has not been the main focus of these industrial policies.

The most important measures to improve innovation in the latest generation of industrial policies arguably were the creation of the "Inova Empresa" (Innovate Company) Program, in the context of the *Brasil Maior* Plan. However, the resources allocated to the Inova Empresa Program were very small compared to the resources allocated to finance other kinds of investments and to all tax breaks provided in the *Brasil Maior* Plan. More recently, innovation has also been supported by the National STI Strategy 2012-2015 (*Estratégia Nacional de Ciência, Tecnologia e Inovação* 2012-2015 (ENCTI)). In this strategy, several actions target innovation and improvements in the regulatory framework through reformulation of implementation rules, legal requirements and administrative procedures.

GRAPH 48

Enterprises that received government support for innovation activities by type of support – within innovating firms (2009-2011)

(In %)

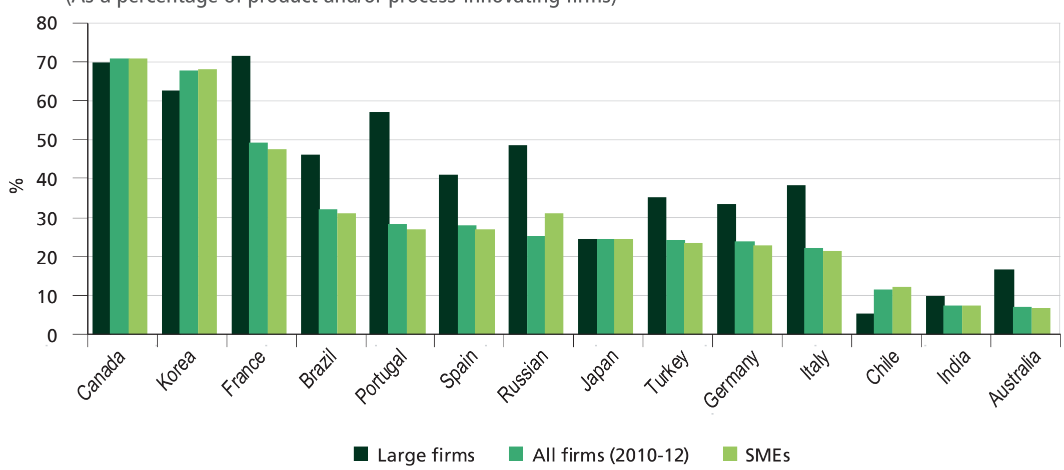


Source: Pintec/IBGE. Available at: <https://goo.gl/pk3gYE>.

GRAPH 49

Firms receiving public support for innovation, by firm size

(As a percentage of product and/or process-innovating firms)



Source: OECD Industry, Science and Technology Scoreboard (OECD, 2015b). Available at: <https://goo.gl/MUnft3>.

Overall, financing has increased and the legal framework for innovation appears to have improved. The number of innovative firms that had some sort of public support to innovate has increased. In 2003, only 19 percent of innovative firms declared that they had governmental support to innovate. This number increased to 34 percent in 2011 (graph 49), which is relatively high among countries for which such data are available. Although all kinds of public support have increased in the latest years, most of them are related to financing machinery and equipment to innovate (graph 48): roughly 75 percent of firms that have received public support to innovate (in 2003 and 2011) have benefited from machinery financing programs, such those operated by the Brazilian Development Bank (BNDES).[38] This reflects the value to companies of incremental catch-up innovation and improving access to existing technology (from abroad or domestic) for most of Brazilian companies. Nevertheless, even excluding firms that received support to acquire machinery and equipment, the number of firms that have benefited from public support to innovation through specific policy instruments increased from 4.6 percent to 8.6 percent of innovative firms between 2003 and 2011. International comparisons show that relatively large shares of innovative firms receive public support for innovation, and this share has increased in recent years (graph 49, OECD, 2015b).

However, the results in terms of innovation performance of the business sector have been relatively weak. This is based on the evidence from the previous sections in terms of business R&D and investment in intangibles as well as in terms of innovation output proxies such as patents and high technology exports. This situation suggests opportunities to improve existing policies for innovation to ensure that they are more responsive and cost-effective in light of national needs. Such a strategic shift could begin with more rigorous evaluations of the actual impact of existing policies relative to their costs, and consideration of alternative policies. It could result in modifications to increase the effectiveness of existing instruments that have been somewhat effective, to discontinue those that have not been effective from a benefit-cost perspective, and to introduce new more cost-effective policies where needed.

4.1 Brazilian innovation policy: the big picture

In the set of Brazilian policies to foster innovation, one can find diverse instruments, such as subsidized credit; tax breaks (including both domestic and international taxes, and the tariff equivalents of non-tariff measures); grants to innovative companies; grants to improve university-enterprise relations; and margins of preference in public procurement including local content requirements, among others.

38. BNDES was created in 1952.

The main sources of funding to S&T in Brazil are detailed in table 1. Some of these resources are not public and some of them are not budgetary ones. The value expressed for credit, for example, is the total loan portfolio of BNDES and Finep[39] to innovation (budgetary resources are used just to equalize the interest rates for innovation with market interest rates). Another example of public policies that do not imply the use of public resources is related to regulatory obligations to invest in R&D. Regulatory agencies in oil & gas and electric industries typically determine that regulated companies have to invest some amount in R&D. This explains the high share of beneficiary firms from these industries using R&D programs (tax/financing of collaborative projects).

TABLE 1
Main innovation and S&T policies and instruments in Brazil (main sources of funding to S&T)

Innovation and S&T policies and instruments (main sources of funding to S&T in Brazil)		Value in 2012 (current R$ – million)
Tax Breaks	Tax exemption created for companies who invest in R&D, created by Law n. 11,196/2005 (“Lei do Bem”)	1,476.8
	Tax exemption for companies in the ICT sector, created by Law n. 8,248/1991 and n. 10,176/2001 (“Lei de Informática”)	4,482.2
	Other tax breaks	464.0
	Total (tax breaks)	6,423.0
Subsidized credit for innovation (disbursements)	Total volume operated by Finep	1,800.0
	Total volume operated by BNDES	2,200.0
	Total (credit)	4,000.0
S&T Public Investment	Subnational (State) investments	7,033.7
	Central government (Federal) investments	18,387.9
	Total (excluding post grad expenditures)	25,421.6
	Total public S&T investment	40,045.0
Counterpart in R&D by companies in regulated sectors (private compulsory investment)	Electricity Regulatory Agency (Aneel) R&D program	392.0
	The National Petroleum Agency (ANP) R&D program	1,226.7
	Total	1618,7

Sources: MCTI. Available at: <https://goo.gl/nekpzyl>; BNDES Annual Report 2013. Available at: <https://goo.gl/KBkFGy>; Finep Annual Report 2013. Available at: <https://goo.gl/o30jrP>; CGEE (2015); ANP Bulletin. Available at: <https://goo.gl/GaKQiB>.

39. Established in 1967 and linked to the Ministry of Science and Technology, the Funding Authority for Studies and Projects (*Financiadora de Estudos e Projetos* – Finep) is the main agency that promotes firm innovation in Brazil. Finep administers the main block fund for innovation funding, financing and risk financing: the National Fund for Scientific and Technological Development (FNDCT, created in 1969).

4.2 Tax breaks

The total tax breaks in Brazil reached around R$ 6.4 billion in 2012 and MCTI estimate R$ 6,9 billion of tax breaks in 2014. Graph 50 shows the evolution of tax breaks for innovation in Brazil since 2000 and the percentage of GDP of these exemptions. According to the most recent estimates by OECD, the amount of fiscal incentives for R&D represents 0.033 percent of the Brazilian GDP in 2013 while direct incentives (funding of Berd) represented 0.0606 percent (OECD, 2015; graph 51). In these indicators, Brazil is the middle range of OECD and other developing countries reported.

BOX 1
Fiscal incentives for innovation in Brazil

The Law n. 11,196 was enacted in 2005 to reinforce changes instituted by the Innovation Law. It was replaced in 2007 by Law n. 11,487, which became known as the "Fiscal Incentives Law" (Lei do Bem). This Law sped up and expanded incentives for investments in innovative activities, authorizing the automatic use of fiscal benefits for companies that invest in R&D and are within requirements, without any need of a formal request.

The special tax regime and fiscal incentives for companies created by the Fiscal Incentives Law stipulate, among others: deductions from income tax and social contributions on net profits from expenses on R&D (between 60 percent and 100 percent), reductions in the tax on industrial products for purchasing machines and equipment for R&D (50 percent), economic subsidies through scholarships for researchers in companies, and an exemption from the Contribution for Intervention in the Economic Domain (CIDE) for patent deposits. It also includes funding to firms who hire employees with Masters Degrees and PhDs. The subsidy can reach up to 60 percent of the salary in the North East and Amazon regions and 40 percent in the rest of the country for up to three years.

Source: Rocha (2015).

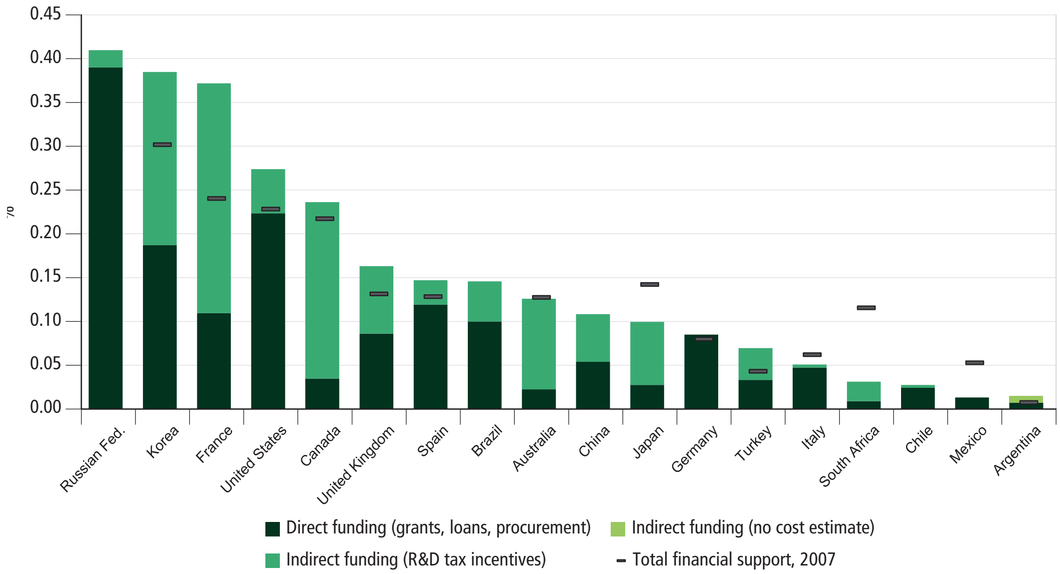
GRAPH 50
Total tax breaks in Brazil (2000-2013)
(In R$ billion and percentage of GDP)

Source: MCTI. Available at: <https://goo.gl/ZAJiUl>; IBGE. Available at: <https://goo.gl/iHJlP6>.

The most important tax exemption is provided to companies in the ICT sector. This incentive was created by the ICT Law or "*Lei de informática*" in 1991 and reformulated in 2001 (Law n. 8,48/1991 and Law n. 10,176/2001). The law establishes some basic production requirements that need to be followed to enable firms to receive the tax reduction.

In 2010, 367 firms benefited from the tax incentives in the ICT sector provided by the ICT law. Most of them were SMEs (table 2). In fact, more than 60 percent of beneficiary firms had less than 99 employees. However, since the tax incentive focuses on the production tax (tax over industrialized products), the value of the incentives are strongly correlated with sales of firms. Therefore, most of total value of tax exemptions was appropriated by the 45 companies with more than five hundred employees.

GRAPH 51
Public policy for R&D, indirect and direct funding of business R&D (2013)
(In % of GDP)



Source: OECD (2015): OECD R&D Tax Incentive Indicators. Available at: <www.oecd.org/sti/rd-tax-stats.htm>; OECD, National Accounts and Main Science and Technology Indicators, June 2015. Direct funding estimates for Brazil based on national sources.

TABLE 2
Total value of tax exemption provided by ICT law in 2010 and number of beneficiaries firms, by size

Size of firm	Tax exemption (current R$)	Number of beneficiary firms
Less than 30 employees	40,995,961	108
30 to 99	149,420,106	122
100 to 249	238,641,019	65
250 to 499	245,257,027	27
More then 500	2,896,450,273	45
Total	**3,570,764,389**	**367**

Source: Evaluation and Monitoring Advisory (ASCAV), Ministry of Science, Technology and Innovation (MCTI).
Obs.: This data were calculated by the Ministry (available at: <www.mct.gov.br/monitor>) in 2012 and, unfortunately, have never been actualized.

Several recent studies have analyzed the impacts of ICT law. According to Souza (2011), the latest evaluation report of the Informatics Law (Salles et al., 2012) reinforces the problems already identified in previous studies: the low international competitiveness of beneficiary firms, the small value added as a share of total Brazilian production, and the low density of science in the research and development (R&D) investments made in the country.

According to Kannebley and Porto (2012), the ICT law has proved ineffective in stimulating R&D in companies, not being able to provide the producers of technology-related goods companies' international competitiveness in their ICT products. Moreover, the "Lei do bem" shows positive results, albeit modest, with an average impact between 7 and 11 percent of increased level of investment in R&D&I to domestic companies. There are a few other studies finding positive impacts of the "Lei do Bem" on R&D investments of beneficiary firms. These studies reject the hypothesis of crowding out and suggest the existence of an additionality effect related to the tax breaks (for example, Shimada, Kannebley and De Negri, 2014).

In the first year of implementation, the "Lei do Bem" reached very few firms. This was a source of criticism in relation to the effects of this instrument. In fact, in 2006, only 130 firms have benefited from this instrument. These firms received around R$ 200 million in tax exemptions and invested around R$ 2.1 billion in R&D. The number of beneficiary firms grew to 639 firms in 2010, investing more than R$ 8.6 billion in R&D and receiving around R$ 1.7 billion in tax exemptions. In total, more than 1,000 firms have benefited from the tax incentives of the "Lei do Bem".

TABLE 3
Total value of tax exemption provided by "Lei do Bem", number of beneficiaries and R&D investments of beneficiaries, by year

Year	Number of beneficiaries	Tax exemption (current R$ million)	R&D investment (current R$ million)	Exemption over investment in R&D
2006	130	229.0	2,109.4	11%
2007	300	883.9	5,107.8	17%
2008	460	1,582.7	8,804.1	18%
2009	542	1,382.8	8,331.2	17%
2010	639	1,727.1	8,622.0	20%

Sources: Evaluation and Monitoring Advisory (Ascav); Ministry of Science, Technology and Innovation (MCTI); and Shimada, Kannebley and De Negri (2014).

In spite of the small number of companies, the R&D investments by the beneficiary firms in 2010 (R$ 8.6 bi) represent more than 40 percent of total business R&D investments in Brazilian economy. This fact suggests that the firms reached by this instrument are some of those that have invested the most in R&D in the Brazilian economy, though it does not address the issue of additionality, namely if any of this investment would not have taken place in the absence of the subsidy; nor does it address the issue of benefit-cost, namely if the investment generated social benefits to the Brazilian economy that outweighed the social costs of the subsidy (including the distortions imposed on the economy from raising the resources to pay the subsidy).

One weaknesses of the "*Lei do Bem*" is its exclusion of firms that declare income tax returns based on their presumed profit. Of course, this practice reduces the number of enterprises using tax incentives for R&D, since it is restricted to enterprises that fit the "real profit" tax regime. Because of that, most of beneficiary firms of "Lei do Bem" are big firms with more than 500 employees. These firms represent more than half of total beneficiaries, although there are also SMEs using the tax incentives provided by the Law. Around 1/3 of total beneficiaries have less than 250 employees. However, these big companies (with more than 500 employees) are, according to the Brazilian Innovation Survey, responsible for more than 80 percent of all R&D investments in the Brazilian economy.

Some insights on the role of R&D tax incentives for innovation can also be drawn from international evidence (OECD, 2015). Such work shows, for example, that the benefits of R&D tax support may be skewed. In particular, large, incumbent and multinational firms may be best placed to reap the benefits from such measures. This is due in part to their capacity to exploit international tax-shifting opportunities. It may also be due to the design of the tax incentive itself. For example, if there are no carry-forward provisions, new firms may not be able to benefit.

TABLE 4
Total value of tax exemption provided by "Lei do Bem" in 2010 and number of beneficiaries firms, by size

Size of firm	Tax exemption (R$)	Number of beneficiary firms
Less than 30 employees	2,152,589	19
30 to 99	12,376,832	60
100 to 249	51,119,979	114
250 to 499	63,130,928	100
More then 500	1,598,358,558	346
Total	**1,727,138,886**	**639**

Source*:* Evaluation and Monitoring Advisory (Ascav); Ministry of Science, Technology and Innovation (MCTI). Obs. This data were calculated by the Ministry (available at: <www.mct.gov.br/monitor>) in 2012 and, unfortunately, have never been actualized.

Bravo-Biosca, Criscuolo and Menon (2013) provide evidence of the impact of R&D tax subsidies on the distribution of employment growth in R&D-intensive sectors. This work shows that support for R&D only has a positive impact on employment growth in incumbent firms with relatively low growth rates, while it has a negative effect on firm entry and on the employment of firms in the top of the growth distribution. These results suggest that R&D tax incentives might favor incumbent firms and slow down the reallocation process. The effect of the design of incentives on overall firm dynamism is, therefore, of great importance.

It is therefore important that R&D tax incentives are refundable or contain carry-over provisions so as to avoid overly favoring less dynamic incumbents at the expense of dynamic young firms. The implicit subsidy rate of R&D tax incentives increases with the profitability of the firm and many young innovative firms are typically in a loss position in the early years of an R&D project. Thus, these firms will not benefit from the program unless it contains provisions for immediate cash refunds for R&D expenditure or allows such firms to carry associated losses forward to deduct against future tax burdens.

For the reasons outlined above, grants and other forms of direct support may be valuable as a complementary form of support for R&D, perhaps targeting the firms that are unlikely to benefit as much from tax incentives (e.g. young firms). In other cases it may be necessary to provide direct forms of support for more mission-oriented innovation that has strong public good elements (e.g. public health, climate change, national security). However, in such cases the award selection process must be designed so as to ensure efficiency, avoid rent-seeking activities and avoid problems of adverse selection.

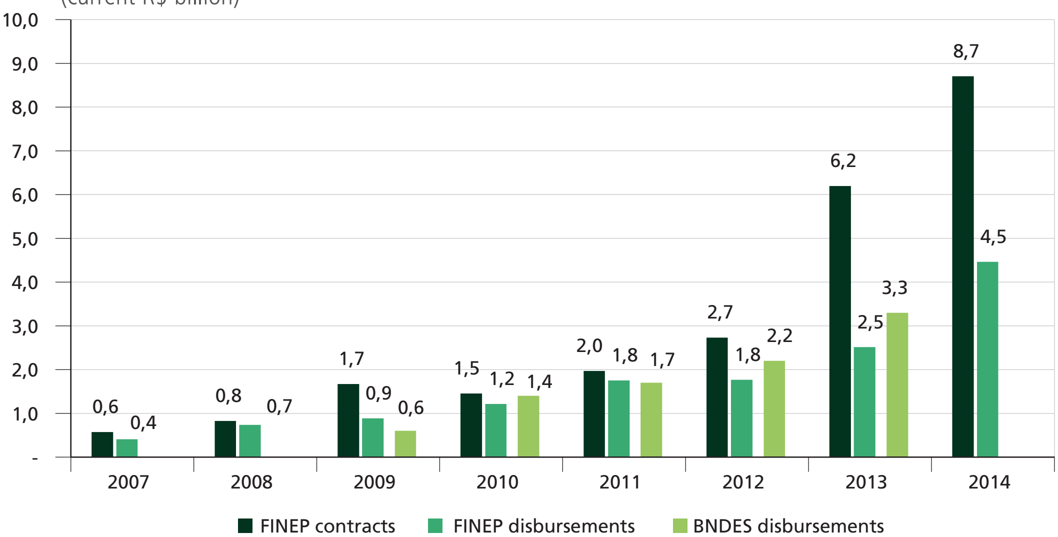
4.3 Credit for innovation

One of the innovation policies experiencing the highest budgetary expansion in recent years was subsidized credit for innovation. This instrument is operated by BNDES and, in recent years, mainly by Finep. Finep, the main innovation agency, has seen its budget to credit increase more than ten times since 2007 (graph 52).[40] Within Finep's budget until 2010, the largest share (R$ 1.1 billion) was the National Fund for

40. Finep is also responsible for the implementation of part of (not all) the resources allocated by the National Fund for Scientific and Technological Development (FNDCT). The next section analyses FNDCT.

Scientific and Technological Development (FNDCT), which is targeted at research infrastructure and academic research, mainly in universities. Since 2010, however, the budget for credit has grown sharply, having benefited among others by the Investment Maintenance Program (PSI) launched after the international crisis of 2008. Jointly with the stability in the FNDCT budget in recent years, the increase due to the PSI raised the share of credit in Finep's budget to more than 80 percent in 2014.

GRAPH 52
Credit for innovation in Brazil in BNDES (disbursements) and Finep (disbursements and contracts) (2007-2014)
(current R$ billion)



Sources: BNDES Annual Report 2014, available at: <https://goo.gl/rR9cwb>; Finep Annual Report 2014, available at: <https://goo.gl/Zgu0tx>.

BNDES expenditures also expanded significantly, from around R$ 0.6 billion in 2009 to more than R$ 3 billion in disbursements dedicated to firm innovation in 2013. However, the amount dedicated to innovation has remained small relative to BNDES' total portfolio that reached, in 2013, disbursements of R$ 190 billion. There is a part of Finep's credit budget that comes from BNDES, in the context of the PSI Program. If one considers, therefore, the amount that BNDES has transferred to Finep, the total disbursements of BNDES for innovation reached R$5.2 billion in 2013 (around 2.7 percent of total BNDES disbursements).

In 2010, Finep's credit portfolio reached around 140 companies, most of them (around 66 percent of the firms) in manufacturing industries. Regarding firm size, most of the loan resources (63 percent) have been oriented to large companies, which are almost a half of all beneficiaries (table 5).

The main programs of subsidized credit created within the PACTI, both managed by Finep, were the "Inova Brasil" which between 2007 and 2010 has supported 213 projects amounting to R$ 4.2 billion; and "Zero Interest" which has financed between R$ 100,000 and R$ 900,000 in value up to 30 percent of gross operating revenues of micro and small innovative companies, with a repayment term of 100 months. Since the growth of credit resources has begun after 2011, there is a lack of studies analyzing the effects of subsidized credit on innovation in Brazil.[41] The former credit program operated by Finep was called National Technological Development Support Program (ADTEN) and had a very limited range. De Negri, Lemos and De Negri (2006b) show that this program used to benefit around 50 firms each year. In spite of its limited range, the impact of the program on firms' R&D investments was found positive and significant, suggesting the existence of an additionality effect. A summary of impact evaluation studies is reported in the annex.

TABLE 5
Total value of loans by Finep in 2010 and number of beneficiary firms, by size

Size of firm	Number of firms	%	Current R$ million	%
Less than 30 employees	17	12	30.95	3
30 to 99	15	11	83.84	7
100 to 249	24	17	89.99	7
250 to 499	19	13	236.48	19
More then 500	67	47	768.87	63
Unknow	1	-	7.98	-
Total	**142**	**100**	**1,218.11**	**100**

Source: Evaluation and Monitoring Advisory (Ascav); Ministry of Science, Technology and Innovation (MCTI).
Obs. This data were calculated by the Ministry (available at: <www.mct.gov.br/monitor>) in 2012 and, unfortunately, have never been actualized.

Both with respect to loans and tax incentives, the total number of beneficiary firms has been very low compared to the size of budgets and the size of the Brazilian economy. Furthermore, in spite of the increased importance of SMEs in applications

41. The latest Innovation Survey in Brazil is of 2011. Therefore, to evaluate the impacts of credit on R&D investments and innovation in Brazilian Industry will be possible only after the launch of the next innovation survey.

to these programs, their representation and value of resources absorbed has remained weak. SMEs (and lagging regions) are often unable to apply and obtain public funds, and in many cases are even unable to prepare an application for competitive funds given the stringent eligibility criteria and complex processes of application.

Fundamentally, SMEs often are not well positioned to articulate a project proposal for innovation or improvement and, most of the time, lack an internal innovation or technology manager (or department). This implies that the productivity gap between SMEs and large firms could be widening. According to a recent study on LAC countries, on average, small firms are 22 percent less productive than large firms, and medium sized firms are 15 percent less productive than large firms.[42] While it is legitimate to foster technological change by forefront leaders by better linking them with the public research sector (science), most of the productivity gap is concentrated in SMEs (Ibarrarán, Maffioli and Stucchi, 2009; Hall and Maffioli, 2008), even if productivity in large firms is also a major concern. Importantly, the productivity gap vis-a-vis large firms is significantly reduced when SMEs access to credit, invest in training and ISO certification, that is, through firm capability upgrading.[43]

4.4 S&T public investments

About half of total public S&T investments of R$ 40 billion in 2012 were directed at post-graduate university education. The Brazilian public sector (federal and subnational governments combined) spent around R$ 40 billion on science and technology in 2012, as shown in table 1 above and according the Brazilian Ministry of Science, Technology and Innovation.[44] Around 40 percent of this S&T public investment was targeted at maintaining post-graduate university courses and institutions (at both the federal and state levels).

42. See Pages (2010) for further information on the productivity lag in LAC and decomposition of the productivity growth within and between sectors. More alarming, recent evidence indicates that the productivity gap between SMEs and large firms has worsened in the last decade in Latin American countries.
43. See Ibarragan et al. (2010).
44. Indicators available (only in Portuguese) at: <www.mcti.gov.br/indicadores>.

TABLE 6
Federal S&T investments in Brazil in 2012 (excluding post-grad investments)

Ministries	R$ current million	%
Total federal budget to S&T	18,387.9	100
Ministry of Science, Technology and Innovation (MCTI)	6,640.2	36
Ministry of Education (MEC) – mainly Capes	3,479.9	19
Ministry of Agriculture (Mapa) – mainly Embrapa	2,448.3	13
Ministry of Health (MS) – mainly Fiocruz	2,072.3	11
Ministry of Development, Industry and Foreign Trade (Inmetro and Inpi)	1,041.5	6
Ministry of Planning (IBGE)	1,013.6	6
Ministry of Science, Technology and Innovation – detailed breakdown		
MCTI – total	6,640.2	36
FNDCT (sectoral funds)	2,981.4	16
National Counsel of Technological and Scientific Development (CNPq)	1,515.9	8
Headquarters and MCTI research institutions	1,265.5	7
Space program (Brazilian Space Agency – AEB)	278.1	2
Nuclear program (National Nuclear Energy Commission – CNEN)	515.5	3

Source: MCTI, available at: <https://goo.gl/QiexQb>.

About two-thirds of the remaining public S&T investment, amounting to R$ 18 billion, was invested by the federal government, with the largest share allocated to the Ministry of Science, Technology and Innovation (R$ 6.6 billion). Table 6 presents a breakdown of these federal investments. The first consideration that emerges from these figures is that Brazilian S&T investments are not "mission oriented", in the sense that most of these investments are not linked to Ministries with a specific mission as in other countries (Mowery, 2009). The Ministry of Science, Technology and Innovation is responsible for the biggest share (36 percent) The main agency responsible for the Ministry of Education (MEC) investments in S&T is the Coordination for the Improvement of Higher Education Personnel (CAPES), which means that most of its budget is attached to post-graduation scholarships in Brazilian and foreign universities. A recent program called Science without Borders (*Ciência sem fronteiras*) is included in this budget (but also in the CNPq budget).[45] The program, created in 2011, seeks to promote the internationalization of Brazilian science and technology through the international mobility of students. Since 2011, the program has benefited more than 78,000 students.[46]

45. The program is executed jointly by Capes and CNPq. Therefore, part of regular budget of these institutions is now attached to the program.
46. Because it is a recent program, there is no evaluation of its results yet.

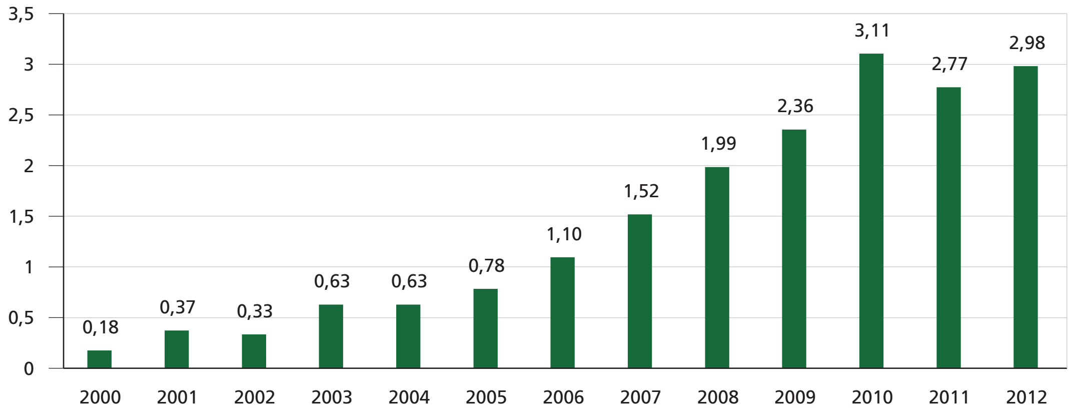
The Ministry of Agriculture (Mapa) invested around R$ 2.4 billion in S&T in 2012, that is around 13 percent of total federal S&T investments. The main agency responsible for almost all of Mapa's investments in S&T is the Brazilian Agricultural Research Corporation (Embrapa) that is also considered a Brazilian success case in terms of technology and innovation. One of the reasons for the success of Embrapa is the fact that it is a very specific mission-oriented research institution. In fact, Embrapa is responsible for several developments that allowed, among other things, the soybean cultivation in the dry and hot climate of the Center of Brazil. Jointly with other state research institutions, Embrapa is the center of a very well-regarded National System of Research in agriculture.

Another important mission-oriented research institution in the Brazilian innovation system is the Oswaldo Cruz Foundation (Fiocruz), under the supervision of the Ministry of Health. Almost all their budget for S&T is attached to Fiocruz. The institution has a broad scope, acting in education and in basic and applied research, especially on public health and related subjects.

In the Ministry of Industry, the S&T budget goes to the Brazilian Patents Office (Inpi) and to the National Institute of Metrology, Quality and Technology (Inmetro). Finally, under the Ministry of Planning is the Brazilian Institute of Statistics (IBGE) that responds for most of the S&T budget of this Ministry.

Since the Ministry of Science, Technology and Innovation is responsible for the largest and most diversified part of the Federal S&T investments, it is relevant to detail the Ministry's spending. The most important source of funding to S&T in Brazil is called National Fund for Scientific and Technological Development (FNDCT). From 1999 onwards, the FNCDT was complemented by a program called Sectoral Funds. These funds were created from taxes and contributions of different industries, including oil and gas (the most important source of funding to FNDCT), health care, agriculture, energy, and aeronautics. The funds are intended to provide expanded and more stable financing to scientific and technological development and promote firm investment in innovation and associations between science and industry for purposes of innovation. Graph 53 shows the evolution of FNDCT's budget execution since the creation of the Sectoral Funds until 2012.

GRAPH 53
FNDCT's total budget execution (2000-2012)
(current R$ billion)



Source: MCTI. Available at: <www.mct.gov.br/indicadores>.

The FNDCT supported a broad set of actions of the Brazilian Government to foster innovation. Most of the budget is composed of grants to universities and research institutions, some of them in partnership with firms. The grants to firms are also funded by FNDCT, and complement the interest rate subsidies by Finep on loans to innovation and the direct investment in innovative companies through venture capital and seed money funds. Around R$600 million of FNDCT resources in 2013 were directly allocated to firms through grants or equalization (table 7).

TABLE 7
FNDCT's budget breakdown (2013)

	Current RS million
Total FNDCT	3,056.1
Support to research and development in universities and research institutions	2,004.9
Scholarships (Science without Borders Program)	307.6
S&T infrastructure	367.0
Equalization	308.3
Grants to firms	345.0
Support to MCTI research institutions	320.1
Other actions	77.8

Source*:* Annual Management Report of FNDCT – 2013. Available at: <https://goo.gl/gPb9Os>.

Although one of the major objectives of the sectoral funds has been to foster innovation and to improve science-industry linkages, most of the budget of the sectoral funds has been allocated to research projects or to research infrastructure in universities and research institutions. In the context of a large evaluation of sectoral funds made by Ipea in 2008 and 2009, De Negri et al. (2009) have shown that only 14 percent of the projects supported by FNDCT (including grants to firms) were oriented to projects in the productive sector, mostly with small firms. These projects represent around 35 percent of the total disbursements of FNDCT. Despite the small share of companies in the disbursements of FNDCT, the impact of the fund on the technological efforts of Brazilian firms has been found to be positive (Araújo et al., 2012) suggesting the existence of an additionality effect.

FNDCT also transfer resources to CNPq to provide academic research grants and scholarships, including those of the Science without Borders program. There was an increase in the amount of resources of FNDCT transferred to CNPq due to this program. According to information from the Annual Management Report of FNDCT,[47] around R$ 1 billion was transferred to CNPq in 2013, including R$ 300 million directly to the Science without Borders program. In 2014, MCTI's estimates indicate an amount of R$ 700 million allocated to the program coming from the FNDCT.

FNDCT has also been used to fund regular programs and policies implemented by the Ministry of Science and Technology in recent years, because of the reduction of the regular budget of the MCTI. An example is the FNDCT resources transferred to the research institutes under the stewardship of MCTI. This amount reached more than R$ 300 million in 2013.[48] Therefore, the overall budget of MCTI remained stable compared to other areas of the government over recent years.[49]

In the next years, FNDCT will suffer a major reduction in revenues that have been traditional allocated to this Fund. The royalties of the oil sector, which have been the most important source of revenues for FNDCT, were reoriented to the Ministry of Education as of 2014. Finally, the Brazilian States invested around R$ 7 billion (one-third of the R$ 25 billion not allocated directly to universities) in state research institutions. Examples of such investments include the Institute for Technological

47. Available at: <https://goo.gl/ZHFdjg>, p. 165.

48. Annual Management Report of FNDCT. Available only in Portuguese at: <https://goo.gl/gBGkYj>.

49. A recent study of the Evaluation and Monitoring Advisory of the Ministry of S,T&I shows that the share of the Ministry's budget remained close to 3% of the total federal government budget during the 2000s.

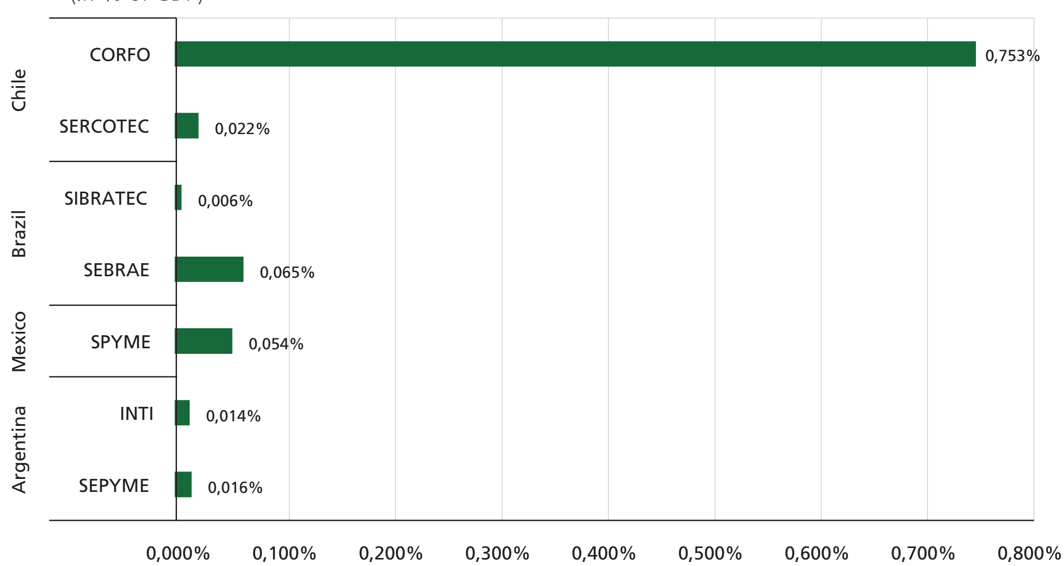
Research (IPT) in SP and the Agronomic Institute of Paraná (Iapar), and in state research foundations oriented to support academic research, such as the São Paulo Research Foundation (Fapesp) and the Minas Gerais Research Foundation (Fapemig).

4.5 Technology extension

Brazil has an important network of public and private providers of technology extension services for SMEs. These include Sebrae, Sibratec, Senai, and regional development agencies. These provide support ranging from training for technology adoption and managerial skills, facilitating information (about markets and technologies, and providers), and supporting or co-financing upgrading, as well as testing and calibration and related metrological services.

In terms of levels of programmatic public support, Brazil currently allocates twice as much for firm-level R&D than for catch-up innovation through technology extension. The magnitude of public support for R&D through formal programmatic channels is about 0.15 percent of GDP (graph 54), relative to about 0.07 percent of GDP allocated to Sebrae And Sibratec, the main agencies for technology extension.

GRAPH 54
Public support to technology extension (SMEs) in selected LAC countries (2012)
(In % of GDP)



Source: Andes, Ezell and Leal (2013).

Sebrae is the most important organization supporting SME development in Brazil. Sebrae is mainly oriented to support measures targeting competitiveness and related to basic technology adoption and digital inclusion. Sebrae also targets design development as a priority action line. Jointly with Finep and Anprotec (*Associação Nacional de Entidades Promotoras de Empreendimentos Inovadores*), another line of activities that Sebrae is supporting is entrepreneurship by financing and supporting the development of the Brazilian incubator system.[50] In collaboration with Finep, Sebrae also finances innovation projects in micro and small enterprises belonging to *Aranjos Productivos Locais* (APL) in the priority areas of the national industrial policy. Sebrae also provides training in management, technology and exports, among others.

Created in 2007 under the PACTI, Sibratec (Brazilian System of Technology) is one of the main instruments used currently by the Brazilian Government to integrate the scientific and technological community and innovative enterprises, with emphasis on the final stage of product development, activities such as scheduling, proof of concept and demonstration plants. The entity aims to support technological development of domestic industries through the following activities: *i*) research and development in innovation processes and products; and *ii*) provision of metrology, extension, assistance, and technology transfer services. Its mission is to create an environment favorable to technological innovation in enterprises through innovation technology centers and technological extension services in various industries and regions of Brazil (box 2).

BOX **2**
Technology extension services in Brazil – Sebrae and Sibratec

The main entity in charge of extension services for SMEs is the *Brazilian Service of Support to Micro and Small Enterprises* (Sebrae)**,** a private nonprofit organization. Sebrae was originally created in 1972 by the government of Brazil, and became independent in 1990. Despite being a private institution, Sebrae develops its activities in collaboration with the public and private sector through its National Deliberative Council, which includes government institutions, business organizations, and research institutions.

Sebrae oversees all SME activities, not just those that support SME manufacturers. While Sebrae has over 4,500 full time employees and an additional 8,000 external consultants, many of these professionals offer consultancy services to help microenterprises (firms with 10 employees or less) interact with government agencies (e.g., file taxes) or broker support from financial institutions. These services, though important, are not specifically technology extension services. Through Sebrae's Brazilian Basic Industrial Technology (TIB) Program, firms can access technical assistance related to logistics, international regulations, standards, and intellectual property. TIB has advisory officers that help firms improve quality and more competitively price their new products. Sebrae has centers in each of Brazil's 26 states and in the federal district of Brasília. It has 750 points of service across the country. With an annual budget of $1.6 billion, Sebrae has 4,900 employees and 8,000 consultants.

(Continues)

50. Crocco and Santos (2011); in Ferraro Zucolotto and Stumpo (2010).

(Continued)

The *Sibratec* program was launched in 2007 and aims to support business technological development through promotion of R&D activities for innovation and supply of metrology and technological extension, assistance and transfer services. It operates through different networks of local agents catering to local productive requirements. Between 2007 and 2009, with resources from FNDCT/sector funds, Sibratec invested € 122.3 million in the implementation of eight state level technological extension networks, six thematic innovation centers and eighteen technological services networks involving 54 institutions and 527 laboratories. Sibratec is made of three types of network: *i*) innovation centers, which are composed of universities and research institutes with experience in business interactions. Its objective is to transform knowledge into commercially feasible prototypes for the creation of new technology-based firms or incremental innovation in existing firms; *ii*) technological services institutes for the provision of metrology, norms, calibration, conformity analysis and essays through the articulation and modernization of existing entities and networks; and *iii*) technological extension networks to stimulate demand for specialized innovation assistance through consultants to make business diagnostics, propose solutions and prepare research projects for submission to research institutes.

Source*:* Andes, Ezell and Leal (2013); Balbachevsky and Botelho (2013).

A new program has been launched to promote firm innovation and technology transfer from research institutions. Launched in 2013, Embrapii aims to promote industrial innovation through the promotion of cooperative projects between national companies and R&D development institutions for the generation of innovative products and processes.[51] Following the Fraunhofer model from Germany, Embrapii is expected to have strong private sector participation, both in funding and management, ensuring a modern, lean and agile, transparent and flexible system of supportive services to business innovation. Inspired by the Embrapa experience, the new entity will focus on meeting the demands of associated industries (MCTI, 2012).

For 2014, the entity had a total budget of R$ 270 million (around US$ 135 million) to launch the program's structure and operations. It is planned that Embrapii should reach a budget of R$ 1.5 billion to be deployed within the next six years (which is about R$ 250M per year). In the first phase (first quarter of 2014), it has issued three public calls with the goal of reaching 23 Embrapii units by the end of the year, including five innovation poles linked to federal institutes and the three units of the pilot project, which have already been tested and have ongoing projects. Through the first call, it has established candidacy eligibility criteria, followed by a rigorous evaluation process which comprises institutional visits, business plan presentation and demonstration that the candidate institution can attend to industrial demands.[52]

51. This initiative started with the discussion prmoted by the Business Mobilization for Innovation – Mobilização Empresarial pela Inovação (MEI) led by the National Industrial Confederation (Confederação Nacional da Indústria – CNI) that meets periodically to discuss public policies to foster innovation – with the participation of the federal government and representatives of academia.

52. Technological Research Institute (*Instituto de Pesquisas Tecnológicas* – IPT), from São Paulo; the National Institute of Technology (*Instituto Nacional de Tecnologia* – INT/MCTI), of Rio de Janeiro; and the Integrated Centre for Manufacturing and Technology of the National Service for Industrial Learning – Senai/Cimatec), from Bahia.

To increase productivity, Brazil needs to enhance public policy actions supporting wider technology diffusion and technology adoption in SMEs. These efforts could emphasize the adoption of managerial practices, dissemination of productivity concepts and best practices; strengthening of linkages with universities and knowledge institutions, and adoption of ICT and energy-efficiency practices. Modernization of production systems such as certification and lean manufacturing/quality systems in manufacturing industries should also be in the agenda of technology adoption. These actions should help increase productive SMEs' growth rates and raise the average productivity of the production system as a whole. This requires reinforcing both quality of supply and fostering a larger demand by firms for these types of technology services.

Although both Sibratec and Sebrae have continued to expand their network and variety of support services, there are several areas for improvements. Both networks should be better embedded in industries and regions, with a higher involvement of the private sector in both financing and managing. 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 in long term agendas for productivity enhancement.[53]

In revisiting and assessing the effectiveness of support mechanisms for technology transfer, equally important is the need to establish to what extent supply and demand side policies complement each other for these purposes and other forms of technical assistance to SMEs. This calls for a better coordination across policies and agencies affecting innovation and productivity.

Supporting SME innovation could benefit from improvements along various dimensions, including helping firms to know what they need (diagnostics), and providing support (financial and non-financial for innovation and technology transfer and supporting productive articulation) through value chains (local and global, and with public agencies through public procurement) and cluster development. These initiatives should benefit from the use of complementary supportive mechanisms such as training and certification.

53. Rogers (2014).

To improve policy effectiveness for technology diffusion and firm upgrading for SMEs, policy oversight and evaluation needs to improve. It is important to reinforce the Monitoring and Evaluation (M&E) system for both Sebrae and Sibratec with proper methodologies and an indicator framework. The apparently large reach that these networks have (Sebrae's network spans 750 units across the country) should allow for a comprehensive and comparative impact evaluation within industries and across regions. Contrary to Finep, technology extension services through Sibratec and Sebrae have not been the subject of an impact evaluation assessment to date. More generally, many public policies for innovation and productivity in Brazil still lack a strong framework for Monitoring and Evaluation (M&E).

4.6 Innovative startups in Brazil

Another important initiative is Start-Up Brasil, which is an acceleration program for young IT firms coordinated by MCTI. The program is part of the TI Maior (Greater Information Technologies (IT)) strategy for the promotion of software and IT services as a means of strengthening the Brazilian innovation ecosystem and bolstering the economy. Start-Up Brasil has been provided with R$ 40 million (Euro13 million) for the entire duration of the program with the goal of leveraging the acceleration of a greater number of startups each year (150 by the year 2014), whose innovative products and services will reach international markets. In 2013, R$ 19.6 million was allocated to the program, in addition to R$ 15.4 million allocated for infrastructure, workshops, consultancies, grants, etc. In 2013, more than 1,600 startups responded to the Start-Up Brasil call. Of these, 118 were selected in two groups and 87 were supported.

Start-Up Brasil identifies accelerators and later startup companies to be paired in the acceleration process. The Start-up Brasil network is comprised of mentors and investors, connected to large companies, to which selected startups are offered access. The Start-up Brasil program incorporates infrastructure and partnerships with other actors in research, development and innovation actors, finally adding public funding. In previous years, most startups have come from the education sector (17 percent), IT and telecom (13 percent) and retail (9 percent) and 47 percent of B2B (business-to-business) are supported, namely projects focusing on solutions for companies.

5 ISSUES FOR DISCUSSION

Brazil's economic model, based on natural resources and low-value added activities, is reaching its limits. Productivity has not been improving at the same speed as output growth and lags behind peer and developed economies. In other words, Brazil is not efficient in the use of productive resources and continues to depend on primary industries. Brazil is at cross-roads and needs to generate new sources of growth based on knowledge and innovation, the tools that drive global competitiveness. In doing so, Brazil faces the challenge of expanding social achievements of the last decade and creating more inclusive growth with enhanced opportunities for employment and income growth nationwide.

This paper exposed the challenges and opportunities of the national innovation system. First and above all, there is an evident gap between the policy efforts undertaken and the resulting innovative performance. With the exception of a few strategic industries, training, new human resources, and expanded S&T competencies – including improved scientific performance and infrastructure – have not yet shown an improvement in nation-wide innovative performance.

Second, the current situation in the private sector indicates a downturn in innovative activities by Brazilian firms: intensity of R&D investment and technology adoption rates (of both hard and soft technologies) is lower than peers' intensities in emerging and OECD economies. This situation, in turn, is hampering opportunities for productivity growth, particularly in manufacturing and services where productivity gaps with respect to the frontier are more accentuated. For example, important parts of agriculture and extractive industries have benefited from the development of sound sectoral innovation systems led by public action and institutions. An important challenge in Brazil is how to replicate such successes in other industries, and more generally, how to consolidate a more competitive national innovation system that will promote business innovation and productivity growth and ultimately support higher incomes and greater wellbeing.

Public policies for innovation have not been missing in Brazil. On the contrary, public support for science, technology and innovation has expanded substantially, with steady increases in public funding and a plethora of policy instruments and programs.

In fact, the level of public support for innovation (particularly to R&D activities) as a share of GDP places Brazil among the countries with the highest levels of governmental support. This situation calls for a review of the effectiveness, efficiency and relevance of current policy mechanisms, and more broadly, of the whole policy making framework for innovation. Despite steady increases in public support for STI, the Brazilian innovation policy model remains "supply-oriented" with a major focus on the promotion of S&T competencies in the public sector. Although demand-side policies have multiplied to promote innovation in the business sector, and several appear to be effective, these initiatives have had a limited impact, reaching a very limited number of companies.

Public investments in S&T (mostly aimed at public sector entities including public universities) are at least eight times greater than the resources deployed for private firm innovation. Yet the impact of public research on industrial innovation and technology development remains limited given the insufficient linkages between public S&T institutions and private firms, and insufficient matching between knowledge supply and business demands. Overall, opportunities for innovation remain weak in spite of a large market and improved S&T competencies and infrastructure.

To conclude, we summarize five of the most important challenges and opportunities that should be addressed in seeking improved innovation performance in Brazil. These priority policy actions are derived from the discussions held at the national innovation seminar, complemented by additional inputs from experts. To improve conditions for innovation in Brazil, the following policy developments need to take place: *i*) stronger market incentives and more enabling legal and regulatory frameworks for business development, including strengthening domestic market competition and revisiting international trade and investment policies to maximize opportunities for global learning and technology catch-up; *ii*) strengthening the governance of public research and technology organizations, their research capacity and orientation, and their linkages with business needs; *iii*) revisiting and strengthening firm innovation policy, particularly regarding technology diffusion and absorption, and more broadly addressing the challenge of improving the demand-related effectiveness of innovation policies; *iv*) making innovation policies more impactful by enhancing coordination across different types of policies for innovation, and across productivity development policies (e.g. linking innovation policies with trade policies, including export, global value chain and cluster policies; and coordinating regional and federal economic policies); and finally *v*) introducing more systematic monitoring & evaluation (M&E) and continuous improvement of policy design and implementation.

The recommendations are not an exhaustive list of concerns, but rather illustrative of key issues to help make public policies for innovation more effective in Brazil. Across all of these areas, Brazil needs to engage in more public-private dialogue and partnerships and increase the role of the private sector in institutional oversight.

6 POLICY CHALLENGES AND AREAS FOR REFORM

1. Framework and regulatory conditions

This review examined several areas that Brazil could improve to foster innovation and new opportunities for business development. The private sector needs stronger market incentives and more enabling business framework conditions to undertake risky investments such as innovation and investment in intangibles (e.g. intellectual property, design and marketing). This entails enhancing domestic market competition – including facilitating the entry and exit of business – as well as fostering global market integration of Brazilian firms. Among the key reforms and actions to improve the regulatory and business contexts for innovation are:

- *Brazil needs to continue improving market competition conditions*. This is essential for firm innovation, business development and consumer welfare.[54] Brazil has taken measures to improve competition policy particularly regarding detection and deterrence of cartels. Ever-changing global markets mean global best-practice efficiency is a moving target and the lack of competition dulls incentives to keep up with global targets. Competition is also necessary for industrial policies (including innovation policies) to be effective.[55] Brazil needs to continue reinforcing effective anti-monopoly policies and reduce barriers to entry and rivalry,[56]

54. Market competition and regulations (that mimic competition) can spur innovation thru two mechanisms: *i*) incumbents are spurred to be more efficient; and *ii*) efficient firms enter and grow while inefficient firms shrink or go out of business.
55. Further, market competition is fundamental to effectiveness of innovation policies such as subsidies and grants. Aguion et al., (2012) in a recent paper, show that industrial policies allocated to competitive sectors or that foster competition in a sector increase productivity growth – policies in non-competitive markets are found ineffective.
56. According to OECD's Product Market Regulations, barriers to entry and rivalry increased from 2008 to 2012.

which is one of the main sources of restrictiveness in the Brazilian regulatory framework. Sectors that need an in-depth revision of the regulatory competition framework include infrastructure sectors and services (particularly professional services) where competition restrictions appear now more severe than five years ago. Stronger competition is also essential for improved resource allocation in the economy, which is the key to stronger productivity growth.

- *The legal framework for Intellectual Property Rights protection (IPRs) and its enforcement, and the effectiveness of the whole IPR system, need to improve to incentivize innovation and creativity*. Strengthening the institutional capacity of Impi will require improving the quality of services, registration and administrative capacity (e.g. reduction of backlog in patent applications), information platform development, data digitalization and online service development (e.g. trademark registration and patent databases), and engagement in promotion and outreach programs through regional services and awareness-raising campaigns.
- *Reformulate the Brazilian Procurement Law (Law n. 8,666) to foster R&D and technology services acquisition by public organizations through private suppliers.* The law establishes, as an exception, the possibility of public purchase of R&D, but there is no special part devoted to R&D acquisition as there is for instance in the American Federal Acquisition Regulation – FAR or any emphasis on private provision. One of the main challenges of these policies is to reach local suppliers besides Public Labs or "national champions". There is a great potential though: public expenditures are still very important in energy, health and infrastructure sectors, among others.[57] Finally, the use of civilian technology offsets must also be enhanced.
- *To facilitate firm learning from global markets and accelerate the formation of innovation capabilities, Brazil needs to revisit current trade and foreign direct investment frameworks to align them more with the needs for technology transfer and catch-up.* With the *Brasil Maior* Plan, trade protection measures have increased and average tariffs on capital and intermediate goods in Brazil are some of the highest in the world. This situation restrains opportunities for Brazilian companies to acquire the best technology in global markets and learn from them ("technological learning"). It also prevents collaboration in the generation of new technologies with top global partners, which in turn hinders the development of innovation capacity in domestic firms. Tariff reduction is associated with stronger innovation

57. Oil and Gas sector responds for 46% of industrial investment and 10% of Brazil total investment between 2010-2013, mostly investments Petrobras.

activity in firms and imported inputs contribute to quality upgrading of local producers. Tariffs on capital goods and equipment as well as Non-Tariff Measures (NTMs) need to be reduced or eliminated (ie. LCRs). These measures typically restrict access to world-class intermediate products and hurt the competitiveness of firms. Services are of growing importance for trade, as these are an important source of product differentiation and competitiveness.

2. Public research and industry-science collaboration

In developed countries, public research laboratories and public investment in university research are a vehicle for governments to shape the priorities of its broader industrial, technology and innovation policy and endow the business sector and society with new technological solutions and competences. In Brazil, important gaps and deficiencies remain that hinder the development of industry-science linkages and the build-up of S&T capabilities for business innovation. One of the political difficulties is that public research in Brazil still has a strong academic bias, with a weak presence of engineering and applied sciences. With the exception of a handful of institutions, public research shows persistent difficulties to operate in collaboration with firms. This situation is exacerbated by the low absorption of researchers by the private sector, which hinders the development of R&D capacity in firms and the possibilities for industry-science collaboration on innovation.[58] The following reforms and actions are deemed crucial to leverage the impact of public research on business innovation:

- *There is a strong need for a long term Technological Development Plan with investment concentration*. Investments in ST&I in Brazil are too fragmented. It is important to focus these investments in just a few technology areas, namely those with the highest impact on the economy and development. These areas must be defined through a national discussion and not by the lobbying activities of a few groups.
- *Brazil needs to reinforce research capabilities in Engineering and Applied Sciences to boost technological performance. One of the main structural reasons behind the difficulty of translating science to technology is the weak development of applied research and the lack of engineers*. The main factors driving this performance are the insufficient education in STEM (Science, Technology, Engineering and Mathematics) at the secondary level and a concentration of these human resources in the public sector to the detriment of the enterprise sector.

58. The low numbers of researchers in industry – as opposed to public sector – indicates that incentives to go into the private sector are not as strong as those provided by public research organizations.

- *The Public Research system (and participating institutions) needs to have a better balance between "mission-oriented" research and curiosity-driven research. It is important to strengthen more "mission-oriented" research in line with international standards of research excellence and international practices including systematic research performance evaluation (e.g. the United Kingdom Research Excellence Framework)*. This will entail a revision of steering mechanisms (block/institutional funding and competitive funding schemes), placing mission-orientation and problem-solving as key criteria in funding and governance including legal frameworks governing responsibilities, autonomy, accounting and management. The governance of universities and public research organizations needs to be reformed to make the system more mission-oriented, more accountable and performance-driven. This will require the development of institutional strategies for R&D and technology transfer that will need to consider the full range of mechanisms for knowledge transfer and commercialization[59] This will entail a revision and update of the Laws governing public research organizations (and organic laws). It is also important to facilitate the ways for researchers and professors in public institutions to work for companies. The new S&T Code (in review at the National Congress) addresses some of these legal deficiencies.
- *To improve industry-science linkages for innovation will require widening the approach to technology transfer and boosting strategic R&D collaboration through long-run schemes (e.g. consortia and centers of excellence) in strategic areas for Brazil's economy*. Widening the approach to industry-science linkages means reinforcing traditional channels of knowledge transfer such as personnel mobility (between sectors) and industry-science joint education and training programs (or services), as well as engaging in technology extension services. The latter are particularly relevant for universities that are not R&D intensive but have engineering and managerial competencies. This approach also entails consolidating public-private partnerships through sectorial innovation networks; R&D collaboration and technology consortia; joint labs and infrastructure; data platforms, licensing and spinoffs; and extension services and quality support services.[60]

59. The system would benefit from a more rigorous evaluation system of the results derived from publicly-funded research, their transfer to industry so that benefits accrue to society as a whole, and more broadly, indications of the impact of public investments in S&T on business innovation and economic development. At the level of researchers, career development should be merit-driven with proper recognition of scientific achievements, international experience and engagement in technology transfer activities.
60. Enhancing mobility of S&T personnel (two-ways) could take the form of co-sponsored exchanges addressing: *i*) training for the development of new skills and the use of new infrastructure; *ii*) testing new methods and joint R&D activities; *iii*) Msc and PhD research studies in industry; among others.

- *Improve and streamline legal frameworks to facilitate industry-science collaboration.* There is some level of legal insecurity in industry-science collaborations. The intangibility of the relations between firms and public institutions are not well understood by controls organs and by the society as whole. As a consequence there is a superposition of laws regarding the theme. A single and simplified legal code could resolve the situation.

3. Firm innovation and demand effectiveness

Several questions emerged in the discussion at the national seminar on how to improve firm innovation policies, such as whether the current policy mix has been appropriate for business demands (and addressing firm heterogeneity) or whether there is a problem of implementation that has been hindering policy impact. A wide consensus exists around the need to review the approach to firm innovation policy along at least these three lines: *i*) firm innovation policy in Brazil should be more stimulating and responsive to broader business demands for technology adoption and absorption; *ii*) innovation policies in Brazil need to more balanced between demand and supply incentives; and *iii*) policy mechanisms (including existing ones) need to more inclusive and reachable by SMEs, including new firms. Solving these questions requires a diligent revision of how policies are being implemented and a better understanding of barriers that dissuade the demand and use of policies by SMEs.

The policy for firm innovation should have a better balance of policy measures and resources allocated to technology transfer and adoption (and incremental, catch-up innovation) compared to R&D-based frontier innovation. This issue highlights the need for the development of an effective "national technology extension system" addressing the needs of manufacture and services industries. Overall technology extension services are underdeveloped in Brazil, with the exception of agriculture extension which has successfully been led by Embrapa.

The policy review highlighted the lower propensities of adoption of new technologies by Brazilian firms, and gaps in terms of support for technology transfer, extension and adoption by firms across the economy. In terms of managerial skills, even the largest companies Brazil lag significantly behind peers from other countries. In terms of levels of programmatic public support, Brazil currently allocates twice as much support for firm-level frontier innovation relative to catch-up innovation, as allocated to Sebrae and Sibratec, the main agencies for technology extension. The new steps that have recently been taken with the creation of Embrapii to promote technology transfer and catch-up innovation may be a step in the right direction.

Lastly, the review showed that engineers and medium-level technical skills are missing. This is a problem because qualified human capital remains a critical determinant of business innovation. Most firm-level innovation is actually incremental (or catch-up) in nature[61] and therefore relies on a broad range of skills across the workforce. Brazilian companies often declare that there is a lack of engineers with experience to successfully lead projects in firms. Brazil has taken steps to fill the gap in engineers and technicians. The number of new engineers has been growing faster than GDP and total employment and new programs for vocational training have been created recently. Measures should be taken to accelerate integration of new human capital resources to the productive sector.

In terms of types of demand-effectiveness, the review showed that the largest public expenditures supporting firm innovation, credits and tax exemptions are mostly used by large firms and those firms are already among the most innovative in the country. Although the evidence indicates that these instruments are effective in fostering firm innovation activities, it seems that they are not stimulating (or are not suitable to promote) significant innovation by SMEs; the participation of small firms in some of these programs in terms of value of resources received remains relatively unimportant. Improving policy frameworks for young innovative SMEs can be particularly important, as these firms are an important driver of job creation and account for much of the more radical innovation in most economies.

Among the most relevant directions for a renewed firm innovation policy in Brazil are:

- *Expand public support (funding and technical assistance) to firm technology adoption and incremental innovation through existing funding programs or new separated funding lines (grants, co-financing and credit lines)*. This will involve supporting: *i*) non-technological forms of firm innovation including managerial skills, training and learning projects, and adoption of new business models (e.g. lean manufacturing, just-in-time, quality management systems, energy efficiency, etc.); *ii*) acquisition of technology, engineering and quality services including quality certification,

61. See Garcia-Macia, Hsieh and Klenow (2015).

standards and norms, quality testing, calibration and conformity tests, etc.; *iii*) ICT adoption and acquisition of new equipment and hard technologies; and *iv*) assisting firms in the acquisition of human resources by facilitating links with the education and research system and supporting hiring of new qualified personnel (e.g. engineers and technical personnel) in SMEs.

- *Consolidate the creation of a national technology extension system for manufacturing and services to support technology adoption and firm upgrading through public-private partnerships.*[62] *The definition of technology adoption agendas should be driven by the needs of industry actors and in coordination with participating civic and public organizations. In line with international practices, effective technology extension schemes display multiple partner governance (tripartite public-private and academia), have an important network of extension specialists, and work with industry associations through collective assistance programs and long-term agendas for productivity enhancement. This will also entail encouraging firms' demand for upgrades and incremental innovation by increasing awareness and knowledge of their impact and benefits.*[63]
- *Mobilize actors and resources for the creation of targeted intermediary institutions under public-private partnerships to address market and coordination failures in the development of upfront innovation (R&D based) – with a focus on applied pre-competitive R&D*. This may involve transforming or creating new units for applied R&D in existing public research and technology organizations to support firms in R&D activities (through R&D contracting, product and prototype development, quality testing and calibration services). This initiative could also consider the organization and creation of centers of excellence or virtual technology (R&D) networks. The recent creation of the National Knowledge Platforms Program goes in this direction.[64]

62. This type of initiative is complementary to the previous point but this one follows a sectoral approach – whereas the former may be more neutral (targeting all firms or SMEs) and engages private sector in the financing and governance of specialized technology transfer organizations or intermediaries.

63. To encourage technology adoption and increase demand for policy instruments by SMEs, demonstration programs (for instance, targeting the adoption of management techniques such as 5Ss, lean manufacturing and quality systems) should be undertaken jointly with industry associations, including collective interventions and joint implementation with industry and SMEs chambers and regional economic organizations (e.g. see Profos programs of Corfo in Chile). Complementary incentives (e.g. financial support to the hiring of innovation specialists in firms – see Colombia and Chile's support schemes for innovation management) for project preparation and the provision of technical support in the preparation of applications could help stimulate SME's demand for innovation.

64. According to the Presidential Decree n. 8,269/2014 (article 2), a "Knowledge Platform" is defined as the enterprise, consortium or private nonprofit organization that represents a public-private partnership oriented to the provision of solution for a specific technical problem or to the development of innovative products or processes of high technological risk (art. 20, Innovation Law).

- *In defining next steps for technology transfer policy (including extension and R&D services), it is important to capitalize on the recent experience of Embrapii (Brazilian Enterprise for the Industry Research and Innovation).* Authorities would benefit from an evaluation of Embrapii (and its different schemes and networks) – which in turn will help with reinforcing and adjusting the system and potentially expanding it to other industries and regions.
- *To accelerate the integration of new human resources in Science and Technology to the productive sector, Brazilian universities need to develop training and industry placement partnerships for university graduates through, for instance, work integrated learning programs (WIL) (industry internships accounting for credits towards degrees) and professional internships targeting problem-solving projects in firms*. For the latter, universities could engage in extension support services to industries and firms that cover firm productivity diagnostics and support in the conception of new productivity projects such as product and process innovation projects (gestão de inovação) and their management. Overall, the Brazilian innovation system lacks policy and mechanisms to support technology extension and managerial development in firms.
- *To foster the creation of innovation and technology adoption, it is essential to use demand side policies, like public procurement*. Although the limits of the Brazilian law, there are some cases in which the procurement power of the State made the difference (KC-390 air plane, medicines for the universal system of health etc.). There is also room for regulations that fosters innovation and for public procurement process design to support new technologies. Several social challenges could be solved through the procurement of the State (urban mobility, vaccines for tropical diseases and remediation of rivers, lagoons etc.)

4. Policy Coordination

In fostering policy effectiveness, Brazil needs to improve coordination across policies (within innovation policies and among productivity policies) to maximize synergies, impact and avoid duplication of efforts. In revisiting and assessing the effectiveness of support mechanisms for technology transfer and adoption, it may be equally, if not more important, to establish when supply and demand side policies should work together in assisting industry innovation needs, and when a joint agenda linking innovation and complementary productivity-upgrading polices may be desirable. This calls for a better coordination across policies affecting innovation and productivity. Two relevant examples of policies that would benefit from coordination are

- *Innovation and trade policies – these are complementary policies (e.g. the impact of joint policies is larger than the impact of a single policy) and should therefore work together in the formation of new global market advantages and firm upgrading to successfully integrate Brazilian firms in global markets and value chains. Innovation policies targeting firm innovation should move from promoting "inward looking" behaviors and become promoters of "outward development". In this sense, R&D policies could place a stronger emphasis on supporting the creation of globally competitive advantages and product innovation projects targeting global markets. In terms of innovative startup development, policy instruments should also target global market penetration and global linkages (e.g. international expertise and finance) to increase possibilities for startup development in global markets. Accelerators and global connection programs could help move startups to this level.*
- *Innovation and cluster policies: both policies exist in Brazil and could enhance their impact through the combination of instruments (e.g. not only innovation policies, but also other productivity policies such as training) forming policy portfolios to support productive development and competiveness of clusters (or industries).* Clusters catalyze innovation through different ways: through knowledge flows and spillovers (e.g. through mobility of personnel and inter-firm value chain linkages);[65] entrepreneurship by boosting new enterprise formation and start-up survival; and by enhancing firm productivity, income-levels, and employment growth in industries; and thereby positively influence regional economic performance
- *Overall, to improve coordination across innovation and productivity programs, both institutional mechanisms (e.g. for overseeing and coordination) and joint implementation schemes should be considered.* Brazil could improve coordination of policy programs through: *i*) horizontal mechanisms through, for instance, an inter-ministerial committee for innovation; *ii*) interactive mechanisms across implementing agencies, such as joint implementation of programs and cross-agency participation in project evaluation; *iii*) improved management and coordination through the use of joint data procedures such as shared application procedures online and information databases;[66] and *iv*) use of productivity mentors or managers (e.g. Spring Productivity Office in Singapore) directing firms' to relevant policy programs and consolidating multi-support schemes of firm assistance.

65. See Uyarra and Ramlogan (2012) for a review of this evidence.
66. In particular, a joint database for the follow-up of beneficiaries and monitoring of productivity performance and programs would significantly enhance synergies across agencies and help avoid data duplication efforts for both firms and organizations.

5. Public expenditure reviews (PERs) and monitoring and evaluation (M&E)

There is room to improve the effectiveness of policies for innovation. The Brazil government could improve policy learning, effectiveness, and accountability through the more systematic adoption of PER and M&E frameworks.

- *Data on ST&I policies must be available*. Brazil suffers from a chronic lack of data in all spheres of policy intervention. The agencies/ministries must dedicate themselves to building adequate information systems and also to adequately train relevant personnel.
- *Improving the monitoring and evaluation performance framework*. This will require an in-depth assessment of M&E systems, their adequacy and alignment with policy objectives, their degree of applicability (and relevant periodicity) as well as their methodological quality and robustness. This work will involve revisiting performance indicator frameworks, their relevance and measurement, and evaluation feasibility (time relevance; cost-effectiveness comparisons, etc.).
- *In addition to measuring the achievement of goals (effectiveness) and the efficiency of programs, the use of M&E would permit to recalibrate (build "adaptive policy mechanisms") and adjust programs. It also would facilitate continuous learning, which in turn facilitates the design of new policy initiatives*. An important aspect for policymaking is to engage in experimentation and be able to learn from failure; in other words, build systems to allow risk-taking, recognize flaws, learn from setbacks, and adapt quickly. Apart from a few limited empirical assessments of R&D programs, there have been few efforts to systematically evaluate policy programs. These efforts pay particular attention to technology extension and its impact on technology adoption and subsequent productivity upgrades.
- *M&E frameworks can be supplemented by periodic (e.g. every four years) PERs of policies for innovation following an approach of continuous improvement of policy design and implementation, as well as a review of the public research system more broadly*. An expenditure review allows the country to consolidate investment data and define how much is spent on innovation, by whom, and to what ends, what the main outputs and developmental impact are, etc. In a nutshell, it assesses the quality of innovation policy efforts of a country and their performance.

Specifically, PERs are designed to provide information to determine the quality of public expenditures on innovation (including support to science, technology generation and dissemination, and firm innovation) and improve decision making through three types of analyses: *i*) a functional analysis of how programs work: to what extent are programs designed around a diagnostic, identification of market failure and the best instrument to address the market failure; are there sufficient resources, and how are programs governed and coordinated; *ii*) an efficiency analysis on what is the goal of each program, how much is being spent, and whether the resources are aligned with the objective, including how users perceive the program; and *iii*) an impact/effectiveness analysis, based on a small sample of carefully-selected programs. The PER seeks to establish the logical links between policy actions, outputs, outcomes and impact, and consolidate an evaluation framework – both at the national and regional levels.

In addition to the PER, a further in-depth review of Brazil's public research system could help to examine the institutional framework for public research, to improve incentives in the public research sector and strengthen the interactions between science and industry.[67]

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67. Examples of such reviews include the OECD Reviews of Innovation Policy, that cover a wide range of countries, including several in Latin America. See: <https://goo.gl/F87MqR>.

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ANNEX

Findings from Impact Evaluations

De Negri et al. (2006a) examined the impact of subsidies (matching grants) from the Scientific and Technological Development Fund (FNDCT) for university-industry collaboration on firms' technological efforts (R&D expenditures), turnover and employees. One hundred and thirty five beneficiary firms from industrial sectors were identified for the period 2000 to 2005. Accordingly, participant firms' spending R&D increased around 50% to 90% more than non-participant firms (in the selection models). Estimation using differences in differences (DIF) with propensity matching (PSM) showed a positive and significant impact of FNDCT on firm R&D intensity (net of subsidy) of 1.63%. No significant difference was found between beneficiaries and non-beneficiaries for the variables (in growth rates) sales, employees, and labor productivity.

De Negri et al. (2006b) showed that firms that benefited from reimbursable funding (credits) from the National Technological Development Support Program (ADTEN) over the period 1997-2005 had in average significant increases in R&D expenditures (levels) between 28% and 39% larger than firms that did not benefit from this program. Beneficiary firms showed increase in sales but no significant impact on productivity, employment or patenting was detected. The authors point out however those results should be taken with care as a main limitation of the program is its limited impact, reaching only 0.07% of industrial firms.

Araújo et al. (2010) evaluated the impact of sectorial funds on R&D inputs (as measured by the number of scientific and technological related employees), employment, and high exports using panel data for 344 industrial firms between 2000 and 2007. They employed propensity matching techniques and differences and difference estimation for key variables using levels and growth rates. They considered "treated" firms as firms accessing any of the instruments provided through sectorial funds: credit access at favorable conditions, grants, and incentives for cooperative projects linking universities and firms. First-differences estimates indicate that the funds do have a positive impact on the technological efforts but a weak effect on firm high tech exports. Impacts for R&D inputs were higher for credit instruments, but authors suggest that this result should be taken with care as richer data and further analysis is needed. Only one marginally significant impact was found for the high-tech exports (after four years of accessing funds). On the other hand, the funds did not have any robust impacts on patents during the period of analysis.

Alvarenga et al. (2012) also examined the impact of sectorial funds on the number of researchers and technicians (PoTech) but focused on two mechanisms: funding for cooperative projects (between universities and research centers) and credits. Their sample of beneficiaries covers the period 2001-2006 and is restricted to industrial firms with five or more employees. Only the total average effect in the year of access was statistically significant: treated firms had an average increase of 1.5% in their R&D investment. This impact increases over time. By analyzing groups (amount levels), significant effects only occur after long periods and for firms that received between \$ 222,000 and \$ 349,000 BR: if those firms had received 1% more resources, they would've invested on average, 4.5% more in *t*-3 and 4.6% in *t*4. On firm size and growth: A 1% increase in sectorial funds resources would lead to 5% more growth in firm size. In period zero, only the decile 8th reports significant effects on firm size: 4.73%. The effects on other deciles occur – three years after access.

In a similar paper, INGTEC Research Group (2013) evaluated the impact of ADTEN, FDNCT and tax incentives in Brazil. Dynamic random effects estimates indicate that the number of researchers and technicians (PoTec) – which is their measure of technological effort of the firm – grow by 4.74 percent due to receiving support from ADTEN, FNDCT, credit or cooperative projects, and peak effects seem to occur in the year that firms receive the support and two years after. Accordingly, with the exception of a subvention program, direct support in the form of credit or cooperative projects fosters more innovative effort than tax incentives. Peak effects appear between the second and the fourth year after receiving the program. Subvention does not have a robust impact on the innovative effort of its direct beneficiaries. Dynamic random effects indicate that subventions may foster a 6.5 percent increase on PoTEc of direct beneficiaries. In both cases, the peak effect seems to occur one year after receiving the programs.

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