CONDITIONS FOR INNOVATION IN BRAZIL: A REVIEW OF KEY ISSUES AND POLICY CHALLENGES

Background Paper for the Workshop on Innovation for Productivity Growth in Brazil - July 1-2, 2015 Brasilia.

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Introduction

The purpose of this paper is to provide information and insights to nourish a discussion to help strengthen the effectiveness of public policies for innovation in Brazil. It is a background paper prepared jointly by IPEA, the World Bank and the Organization for Economic Co-operation and Development (OECD) for the July 1-2 Workshop on Innovation for Productivity Growth in Brazil. The document 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 gaps that remain in the national innovation system and public policies towards innovation.

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 of developed countries. We distinguish indicators of technology adoption and measures of incremental innovation from indicators -inputs and outputs- 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 recent policy developments related to innovation in Brazil – their impact, shortcomings and areas for improvement. While this effort is far from being 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. A final section presents some outstanding issues for discussion.

1. Innovation Performance of Brazil: An International Comparison

Brazil has made remarkable 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% in 2005 to 8.9% in 2013 and extreme poverty fell from 10% to 4% 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 across firms 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 based on low value-added in its primary sector industries to one based on higher value-added based on knowledge upgrading in all industries, including agriculture and mining industries . Further, the major factors that contributed to labor income growth in the last decade – i.e. improved terms of trade related to commodities-- have faded and the current labor income growth trend is not economically sustainable in the long term without increases in productivity.

In achieving this process, improving innovation performance of the business sector is fundamental. Innovation is at the heart of countries' and firms' drive to raise productivity and economic growth. International experience has shown that growth is driven not only by physical and human capital accumulation but most importantly by innovation, including catch-up (new to the firm) as well as frontier innovation (new to markets). Innovation is a broad concept that relates not only to the generation and commercialization of new ideas but also to the process of diffusion and adoption of existing knowledge and technologies by all firms, adapting that knowledge to local context.

At the firm level, innovation leads to a more efficient use of resources and market advantages for firms. This is not an automatic process. Innovation –which is the transformation of ideas and their commercialization into new products (goods and services) and processes– 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 global goods and services, capital, technologies and talent), and the ease of appropriation of innovation returns (e.g. intellectual property protection and enforcement).

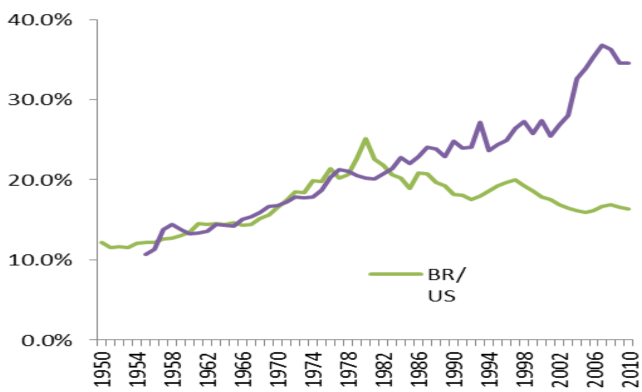
As we will see next, the Brazilian business sector is not investing as much as peer economies and OECD countries in several critical areas of innovation –including in R&D and intangibles, and most importantly in technology adoption. The benchmarking exercise demonstrates that Brazilian firms are trailing 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.

1.1. Overall Performance

Brazil showed economic dynamism and social progress over most of the past decade. Brazil grew at an average rate of 4.4% over the period 2004-2010 compared to 1.9% in the previous seven years. Over the period 2003-2013 over 26 million people were lifted out of poverty and inequality was reduced significantly (the Gini coefficient has fallen 6% in 2013 to 0.54). 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.

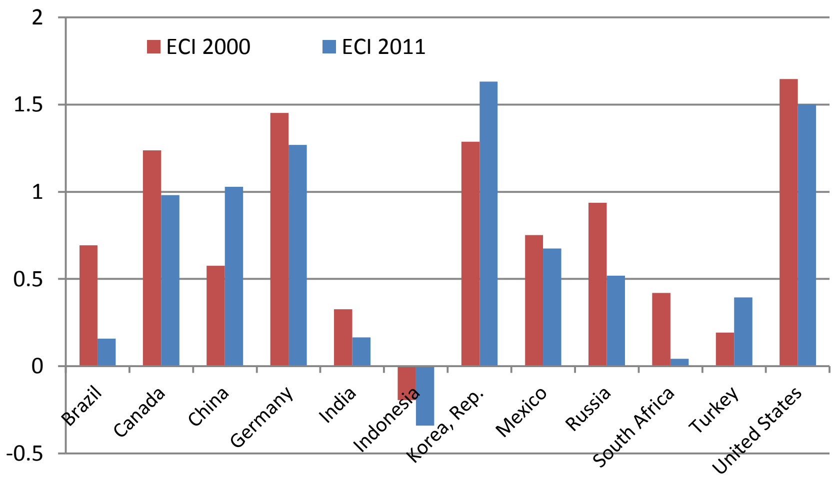
Yet productivity has not been improving at the same pace of economic growth. Figure 1 shows that the gap in productivity (measured as GDP per worker) with respect to the United States remains pretty much at the same levels between 1950 and 2010 – in spite of an important improvement of Brazilian productivity in the early 1980s. Considering GDP per person employed, Brazil had a labor productivity of US$ 19.80 in 2013 while the United States, Germany and Japan had a productivity of US$ 114.90, US$ 79.90 and US$ 75.20 respectively. Even against other leading developing countries, Brazil shows a lower performance. For instance, the labor productivity in South Korea, Russia, Malaysia and South Africa were respectively of US$ 66.40, 37.40, 37.20 and 32.40.

Figure 1: BR/US: PPP converted GDP Laspeyres per hour worked by employees at 2005 constant prices



Source: University of Pennsylvania - Center for International Comparisons of Production Income and Price

Figure 2: Economic Complexity Indicator (ECI) for 2000 and 2011 –Selected countries



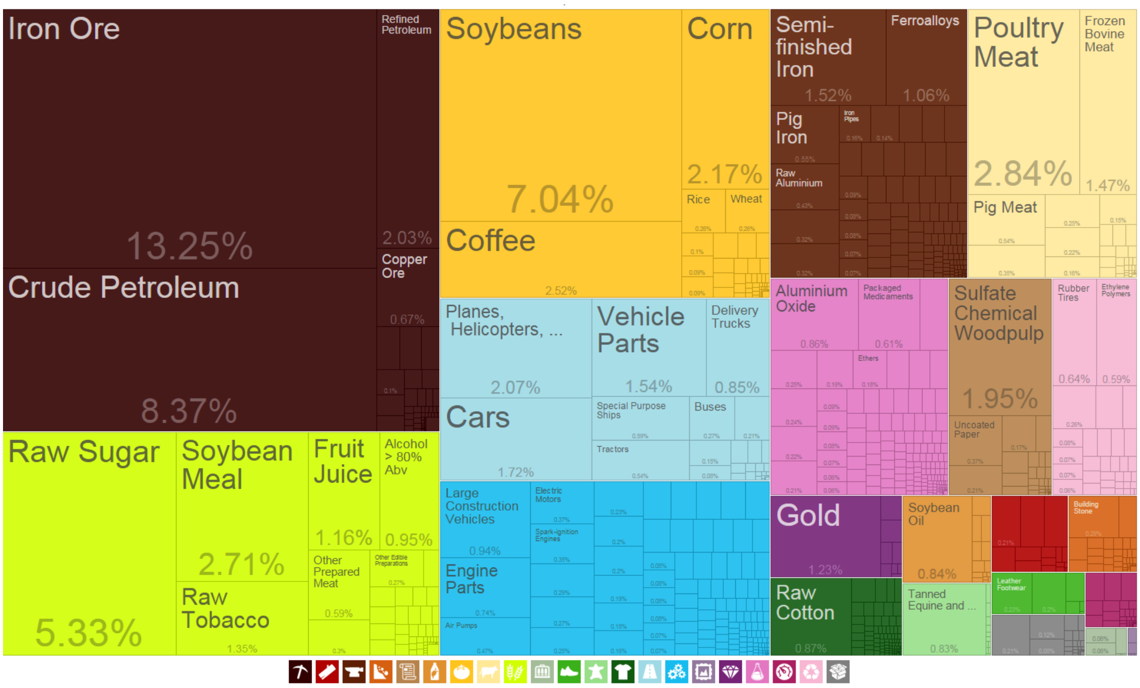
Source: Atlas/MIT, Observatory of Economic Complexity.

Brazil's recent growth has been mainly driven by labor rather than productivity improvements. According to a recent study, 60% of Brazil's recent growth has been driven by labor inputs and demographics while only 40% was due to gains in productivity. In contrast, productivity accounted for more than 50% of GDP in many other emerging economies such as China, India and Russia (McKinsey Global Institute, 2014).

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. According to this definition, competitive countries are those showing a high diversification of their export basket. Brazil is ranked 56th (figure 2) 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 a deterioration of the level of economic complexity, shrinking six times between 1995 and 2011.

Statistics on exports sow 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 (Figure 3).

Figure 3: Products exported by Brazil (% of the total), 2012



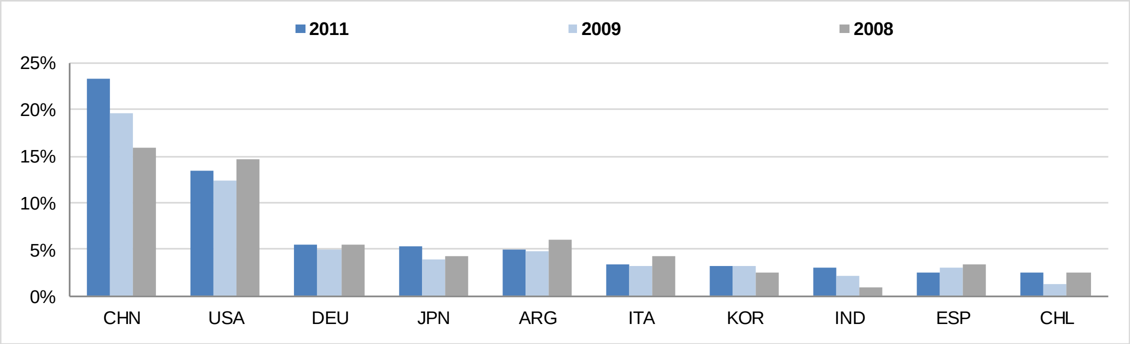
Source: Observatory of Economic Complexity –MIT.

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).[1]

Brazil’s integration in global value chains remains limited, partly due to the lack of a well-developed regional value chain 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 database, 2015). Brazil’s major import and export markets remain outside of Latin America, with the expectation of Argentina, with China alone directly importing one-quarter of all Brazil's intermediate exports in value-added terms in 2011 (Figure 4), pointing to an underdeveloped regional value chain. However, close to half of all exports reflect services content (and one-third of manufacturing exports reflect services content), pointing to a significant upstream contribution of domestic services industries and pointing to the importance of a well-developed and competitive services sector for Brazil’s performance in international trade.

Figure 4: Brazil's domestic value added embodied in intermediate exports

% of total intermediate exports, in value added terms**,** 2008, 2009, and 2011



Source: OECD-WTO TiVA database, June 2015.

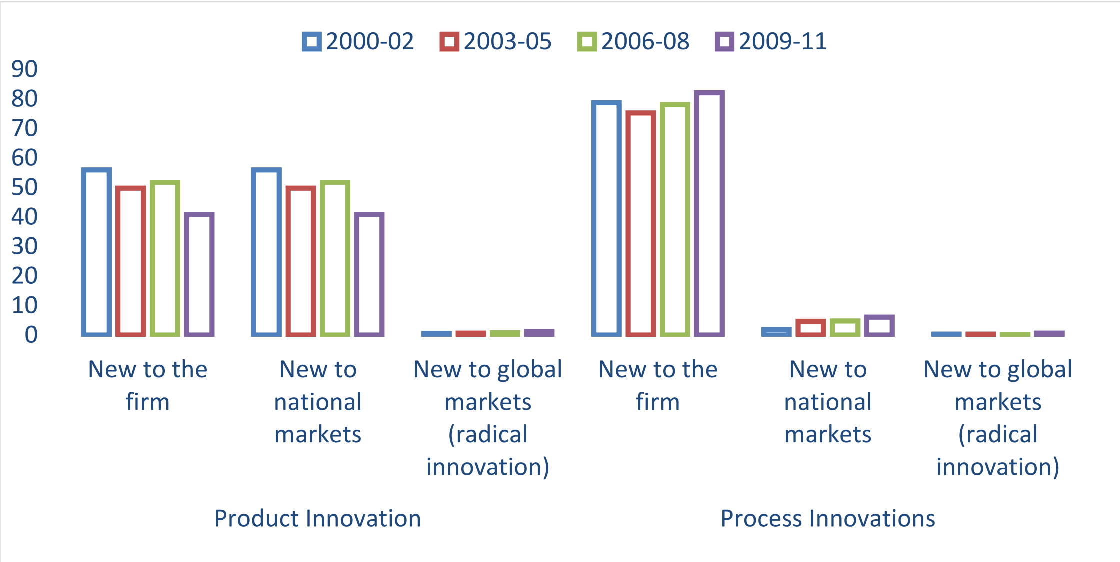
Brazil’s high-technology industries are expanding and this will eventually translate into higher exports if goods are internationally competitive. Over the period 2003-2013, Brazil’s high-technology manufacturing industries grew more than twice as fast as the average for all developing countries, excluding China. Pharmaceuticals, aircraft and spacecraft led this growth. Much of this expansion has been driven by increased foreign multinational activity that seeks 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 satellite.

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 from Ireland (11th), China (29th), Portugal (32th) and Russia (49th).[2] Out of the world’s top 2000 R&D performers, only 8 are Brazilian, although this is more than in some other large emerging economies, e.g. Mexico (1), Russian Federation (4) and South Africa (1) (EU-OECD, 2015).

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 (Figure 4).

In terms of types of technological innovation, process innovation is more frequent than product innovation. More than 80% of companies that reported having innovated have done process innovations where the novelty is specific to their firm, while 50% of companies that have innovated have also introduced a new product, which typically represents novelty not only for the firm but also for the national market. This pattern is consistent across years. There seems to be an increase in the novelty of process innovations over time (that is, they are being reported increasingly as not only new to the firm but also new to the national market), though the changes in levels remain low.

Figure 4: The Nature of Technological Innovation in Brazilian Firms (all companies in the economy, in %), 2000-2011



Source: IBGE.

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%. 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% of national innovative firms applied for patents over the 2006-08 period (Zucoloto *et al*, 2013, based on the 2008 PINTEC innovation survey); this share reached 26.4% for foreign firms and 36.5% for joint national and foreign-owned enterprises.

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, and 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 (Figure 5). 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:

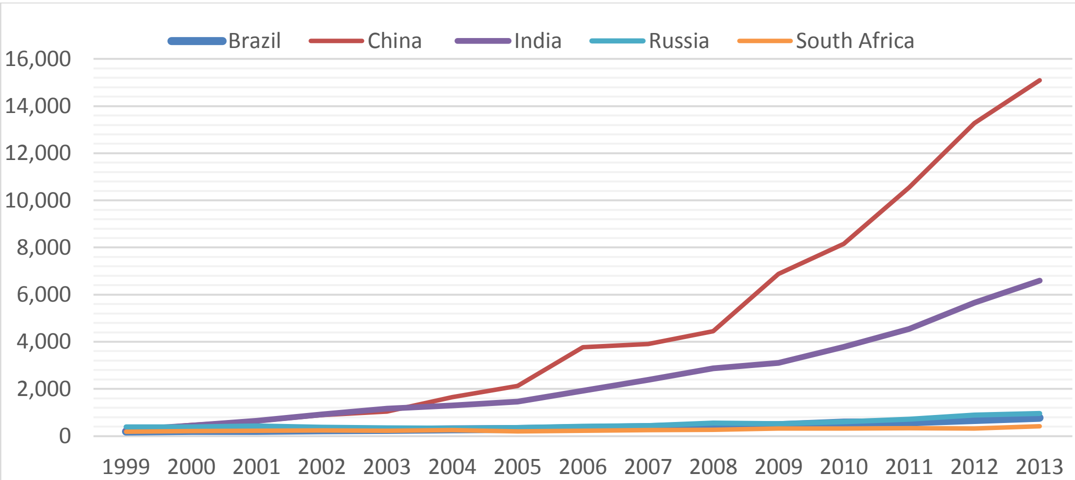
(i) Adequate levels of public funding: Embrapa's expenditures in the last 20 years, at around 1% of Brazil's agricultural GDP compare well with public spending on agricultural R&D in more developed countries, such as Canada, the United States, and Australia

(ii) 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

(iii) 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

(iv) 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.

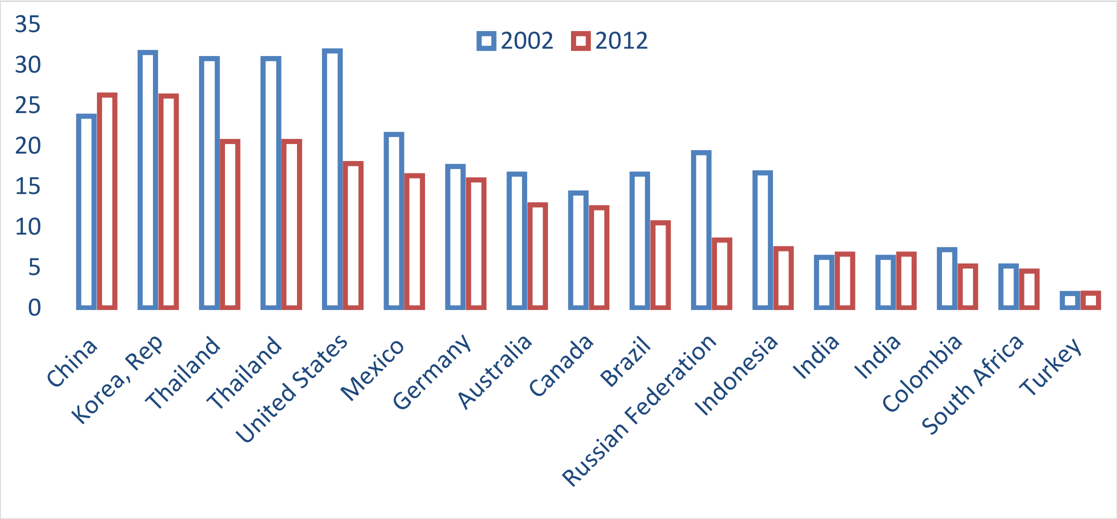
Figure 5: – Patents applications in the USPTO, selected countries. 1999-2013



Source: MSTI

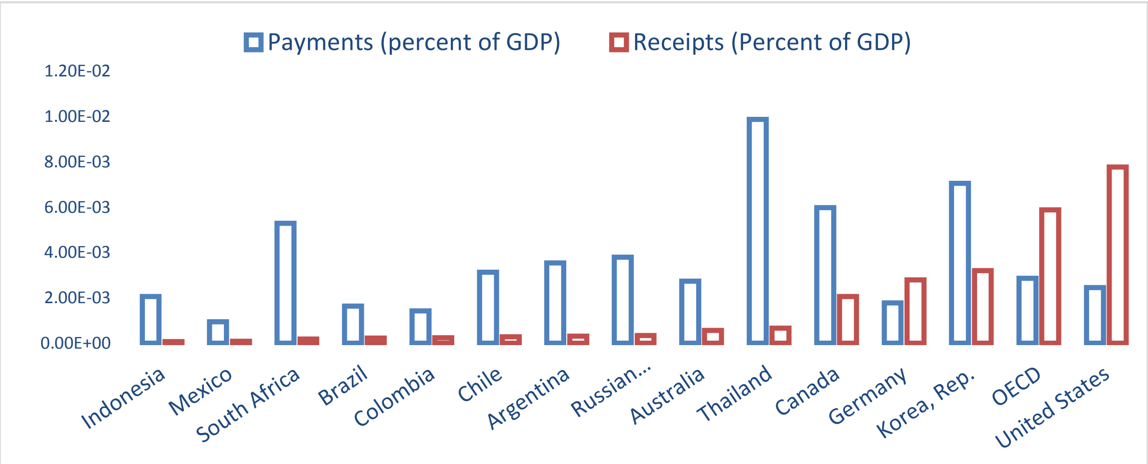
Brazil's relatively weak economy-wide frontier innovation performance is also reflected in the intensity of technology-intensive exports in total manufacturing exports, and of technology receipts and payments. In 2012, only 10% of manufactured goods were high technology-intensive products whereas in China and Korea this figure was 20 and 26%, respectively. Mexico also shows a higher technological intensity in manufactured exports at 16% (Figure 6). And Brazil performs lower than most comparators as well 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 (Figure 7).

Figure 6- High Tech exports, selected countries (% of exports) 2002-2012



Source: World Development Indicators. World Bank, 2014.

Figure 7- Technology Payments and Receipts, selected countries (% of GDP) 2012



Source: World Development Indicators. World Bank, 2014

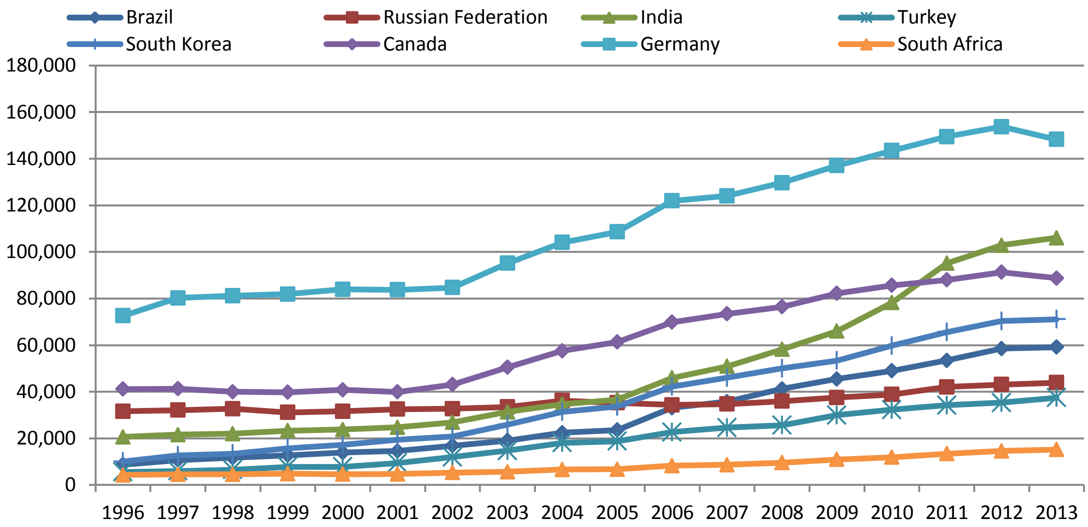
The increase in university patenting in Brazil appears mainly driven by policy changes rather than market incentives. The increase in patenting closely matches the policy reforms initiated in 1996 and those introduced in 2004, which provided further incentives for researchers and institutions to own 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.[3] 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.

In line with the increase in scientific infrastructure, scientific performance has improved in Brazil. In 2010, Brazil produced 2.12% of total scientific publications globally, a huge increase from below 1% in the 1980s (Figure 8). 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.

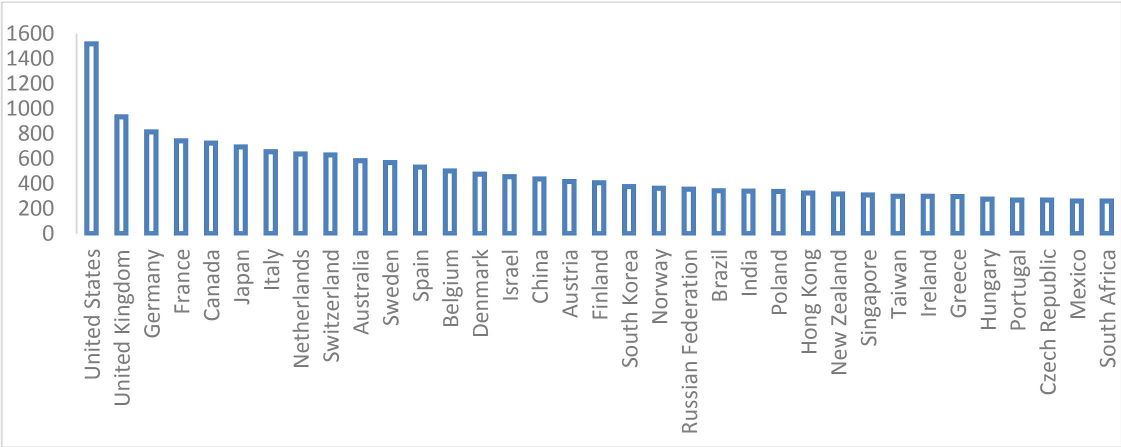
Figure 8: Scientific Publications (total number) over time –Selected Countries



Source: SCIMAGO Online Database, 2014. Period covered is: 1996-2013.

The quality of science, however, remains far from the average of developed countries. In terms of the H-index (citation impact), Brazil is behind China, South Korea and Russia, but ahead of India and South Africa (Figure 9). Medicine and biochemistry are the most influential research areas published by Brazil.

Figure 9: H-Index –Quality of Science, selected countries. 1996-2013



Source: SCImago.

In addition, there is a need for greater integration of Brazil into global collaborative networks of S&T research. Brazil's absolute and relative numbers of co-authorships with international partners in scientific publications, although growing and higher than other emerging economies (such as India or Russia), remain trailing behind developed economies. Between 2000 and 2013, this share has been decreasing (from 29 to 25%).[4] In larger developed countries, international co-publications represent about 50% of scientific publications: in 2013, this share was 45% in Germany and 47% in Canada.

1.2. Technology and Innovation Efforts

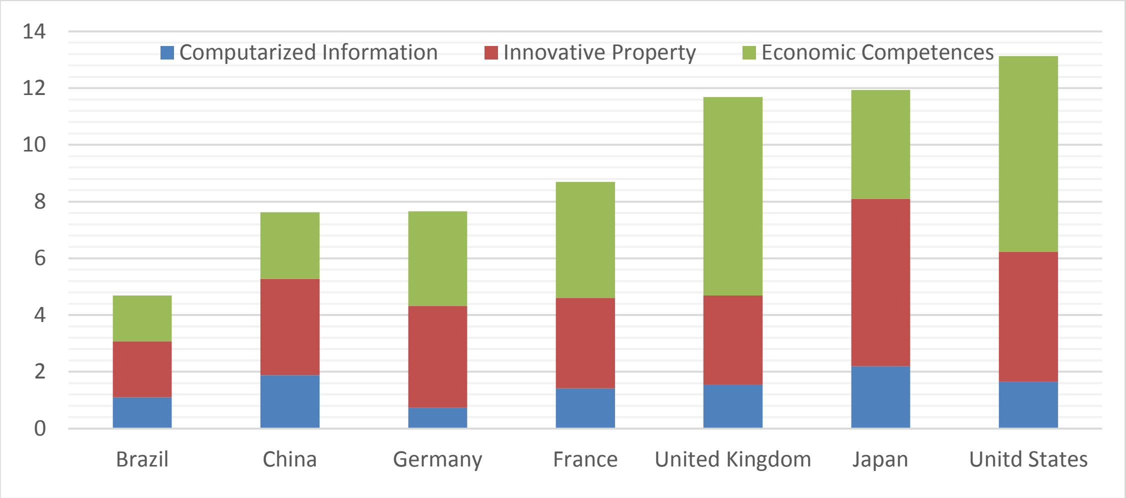
We present an overview of indicators of innovation activities and analyze how Brazil compares with other economies (OECD and emerging countries). We distinguish catch-up innovation activities from those related to frontier innovation (R&D based), including public investment in science and industry-science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

1.2.1. Intangibles and Catch-up Innovation

Firms in Brazil are not investing in intangible assets as much as their peers in leading countries.[5] Spending on intangibles by Brazilian firms averaged around 4% of GDP between 2000 and 2008; this is less than in Japan, the United Kingdom and the United States but roughly similar to Italy and Spain (Figure 10).[6] 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 10 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.

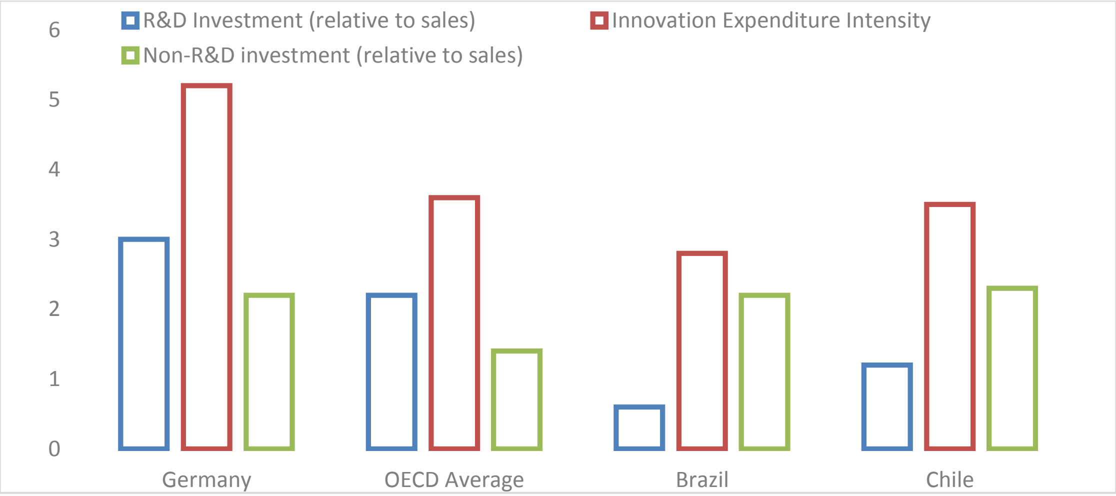
The gap with other OECD economies is also large for other forms of innovative property, in particular new architectural and engineering designs. A comparable measure based on surveys of manufacturing enterprises yields a similar picture (Figure 11): Brazilian firms invest less in innovation than OECD economies, with the gap being particularly large for R&D investment. While manufacturing firms in Brazil invest 2.8% of their sales in such activities, firms in the US dedicate 3.8% of their sales to innovation and firms in Germany invest 5.2% (Figure 11); across OECD countries, more than two thirds of this investment is on R&D activities.[7]

Figure 10: Investment in Intangibles, selected countries (% of GDP and type of objective) -2012



Source: Dutz, Kannebley Jr., Scarpelli and Sharma (2012).

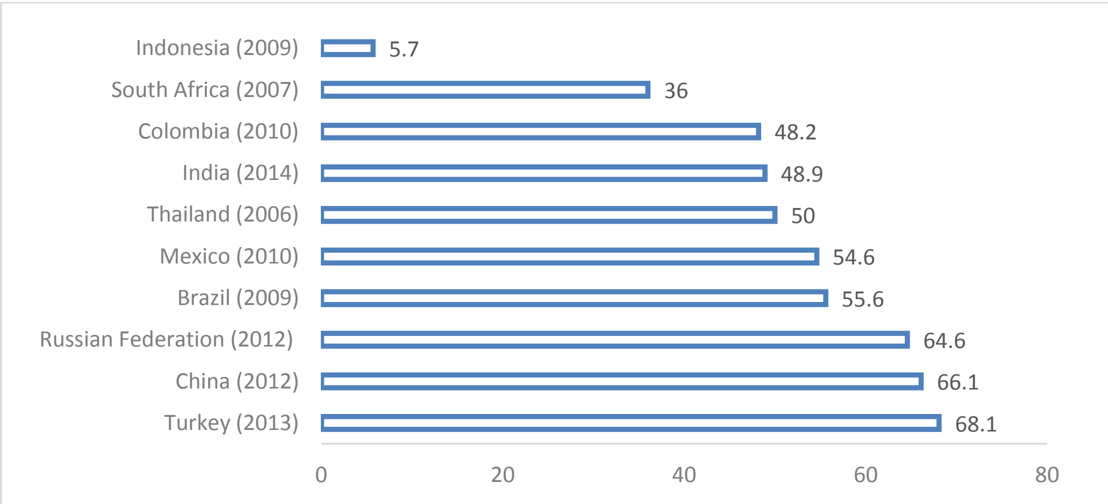
Figure 11: Investment in R&D and non-R&D innovation activities, selected countries (% of sales and type of investment)



Sources: Innovation Surveys for each country: Brazil: 2009-2011 Chile: 2011-12 and data for OECD countries are from OECD (2009). Indicators refer to manufacturing.

The rates of ICT adoption by Brazilian companies is lower than other leading emerging countries such as Russia, China or Turkey, and has strong complementarities with better management practices. While 56% of manufacturing companies in Brazil report to have their own website and 84% of firms use e-mail to interact with clients and suppliers, the comparable figures are 70% and 89% in Turkey, and 66% and 85% in China (Figures 12 and 13). 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 should go hand in hand with other innovation enablers such as managerial skills and human capital upgrading. The gains that ICT could generate are contingent upon parallel investment in these complementary capacities. Returns to productivity are particularly high when firms undertake simultaneous investments in improving organizational structures. More generally, the level of ICT capital intensity (in firms and regions) and its returns on productivity are encouraged by the quality of infrastructure and pro-worker labor regulation.[8]

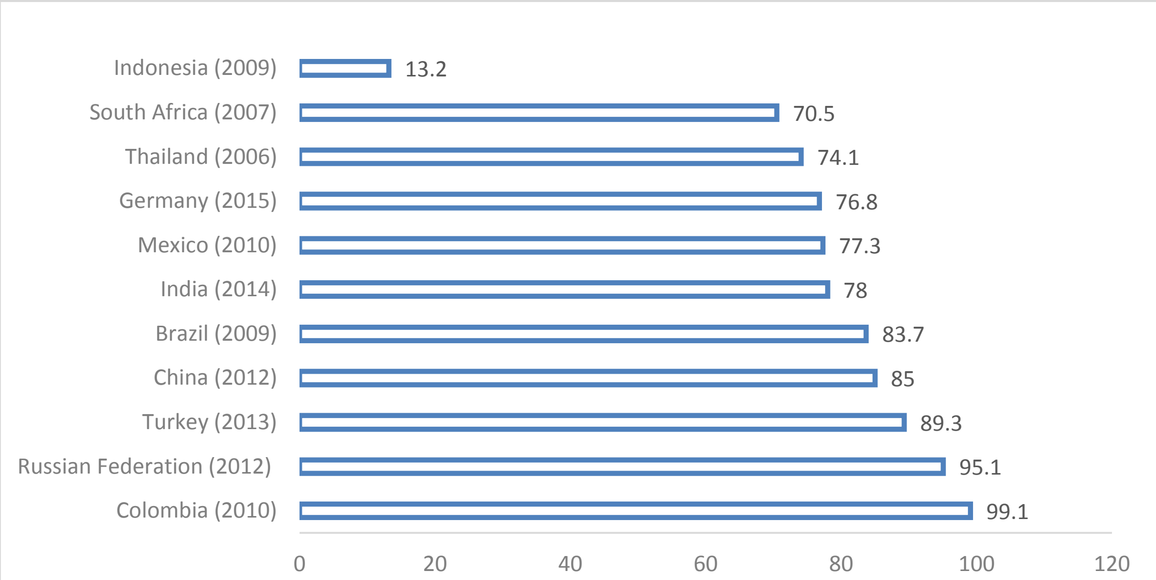
Figure 12: Percentage of firms having their own website, selected countries. Various years



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.

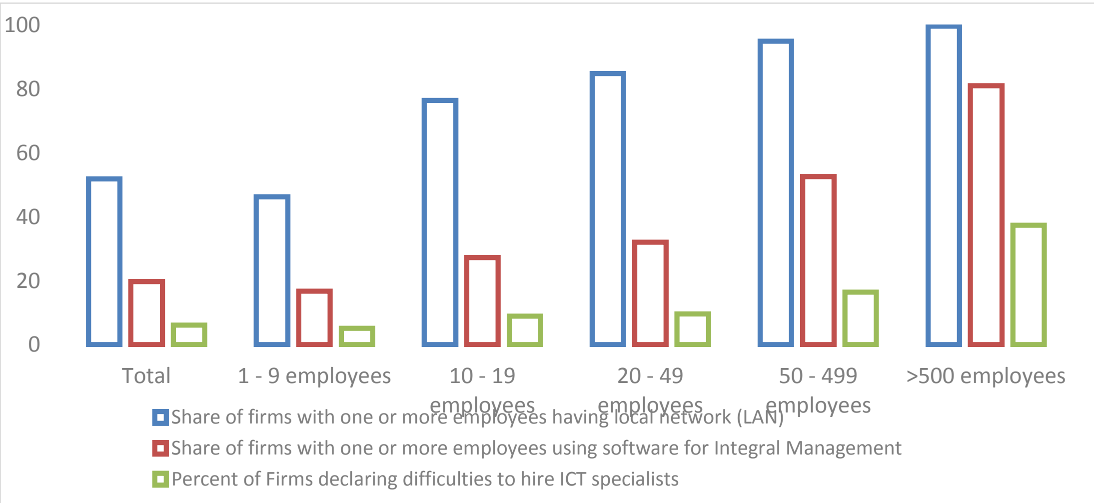
In addition, in Brazil, the adoption of productive ICT (other than internet) investments appears strongly associated to firm size. As size increases, the propensity of firms to adopt ICT expands, reaching the totality of firms using ICT technologies in the segment of largest companies. For instance, this is the case for the use of local networks (LAN) or having implemented software for integral management: this technology adoption reaches above 80% of firms in the largest size group of firms (above 500 employees) (Figure 14). At the opposite end of the firm size spectrum, micro and small companies report about a quarter the propensity of large firms to have productive ICT technologies such as software for integral management or about half the intensity of large firms in the use of local networks (LAN).[9]

Figure 13: Percentage of firms using email to interact with clients/suppliers, selected countries. Various years



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.

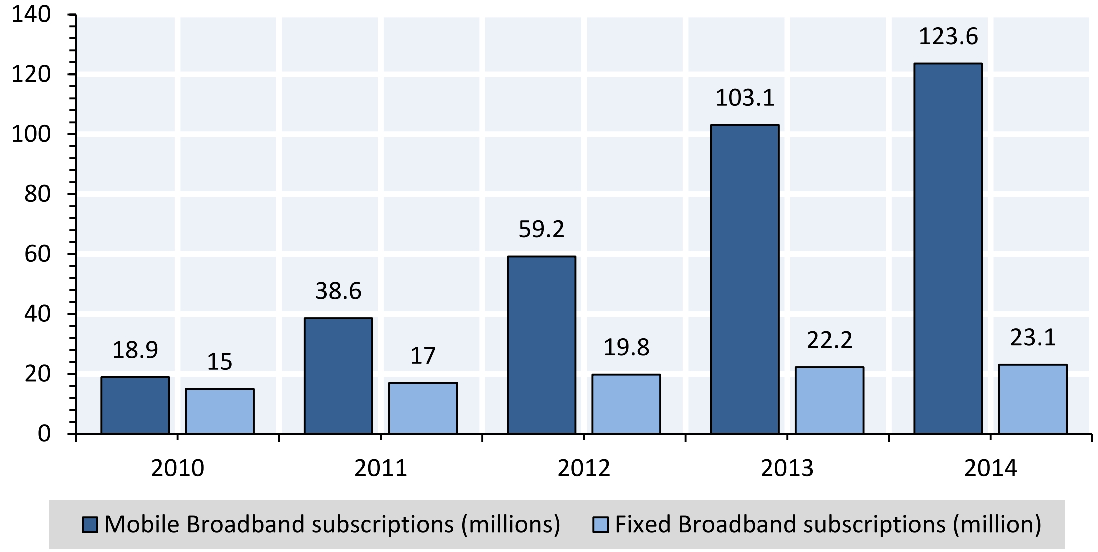
Figure 14: ICT adoption by Brazilian firms by firm size (all sectors of the economy), 2010



Source: IBGE, Diretoria de Pesquisas, Coordenação de Indústria, Pesquisa sobre o Uso das Tecnologias de Informação e Comunicação nas Empresas 2010. Indicators are economy-wide level indicators.

At the same time, Brazil has experienced a rapid increase in mobile communication services in recent years (OECD, 2015). From 2010 to 2014, Brazil has seen an increase of 79% in fixed broadband subscriptions, from 12.9 million to 23.1 subscriptions (Figure 15). Mobile broadband access has increased 825% 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% in 2011 to 31.4% in 2013, with a further acceleration in 2014 (ANATEL, 2014).

Figure 15: Broadband subscriptions in Brazil (in millions), 2010-2014



Sources: Official indicators from the Brazilian Telecommunications Agency (ANATEL), 2014.

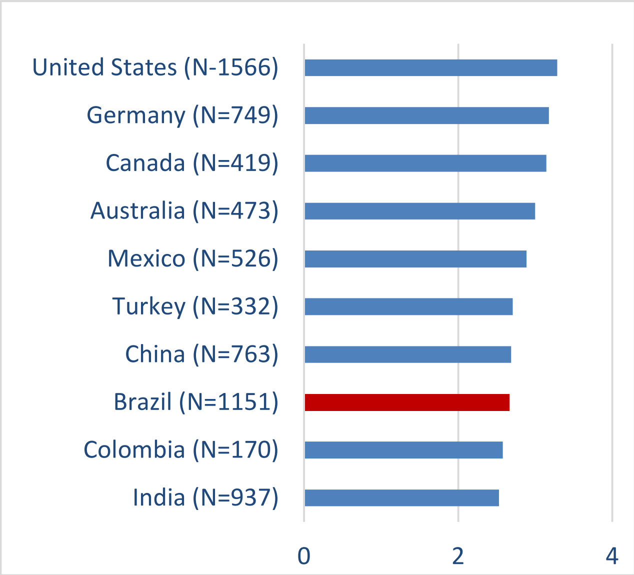
This rapid growth in the use and access of ICTs is an indication of broader changes in the Brazilian economy and society. Brazilians embraced digital media rapidly, being avid technology consumers and engaging intensely in social media platforms. This has contributed to the rapid growth in the use of ICTs. As a whole, the ICT sector is in an ascending curve and has shown resilience throughout the international economic crisis, supported by the 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 its tail of poorly-run firms is fatter than China's. Averages by country of adoption of managerial technologies across firms are displayed in Figure 15 (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 survivors to improve. Regulatory barriers to entry, protection of inefficient incumbents, and having a vigorous competition policy 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 retard them. Second, the human capital of managers also plays a role, measured by the proportions that have college degrees. Finally, the lack of information and knowledge by managers themselves about how well managed their firm is and how to upgrade management practices seems to matter as well.

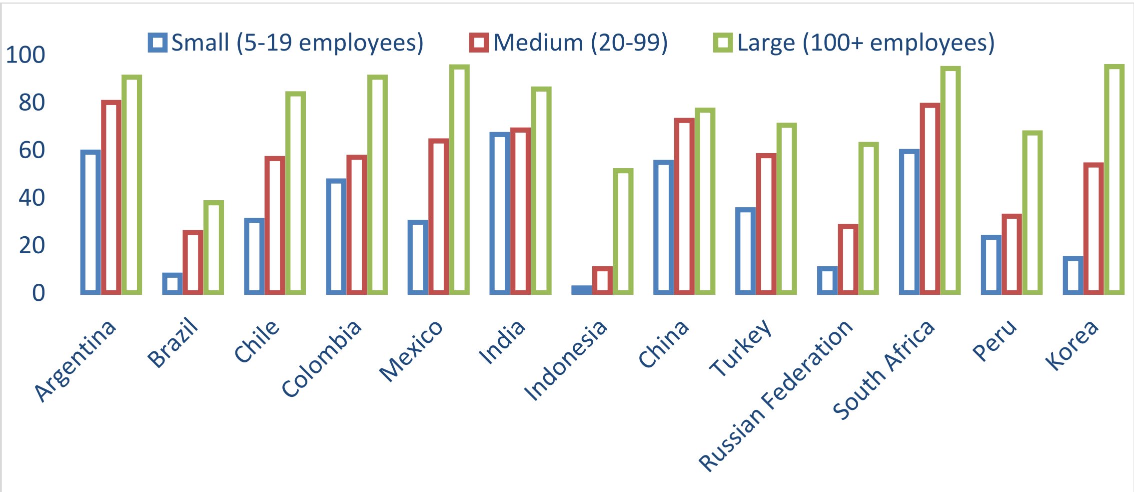
Even in terms of basic managerial practices, Brazilian companies are less engaged than firms in other emerging economies. In Figure 16 we report the percent of firms having annual financial statements reviewed by an external auditor. The rates of firms reporting such a practice are dramatically lower 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.

Figure 15: Average management score by country, manufacturing



Source: World Management Survey.

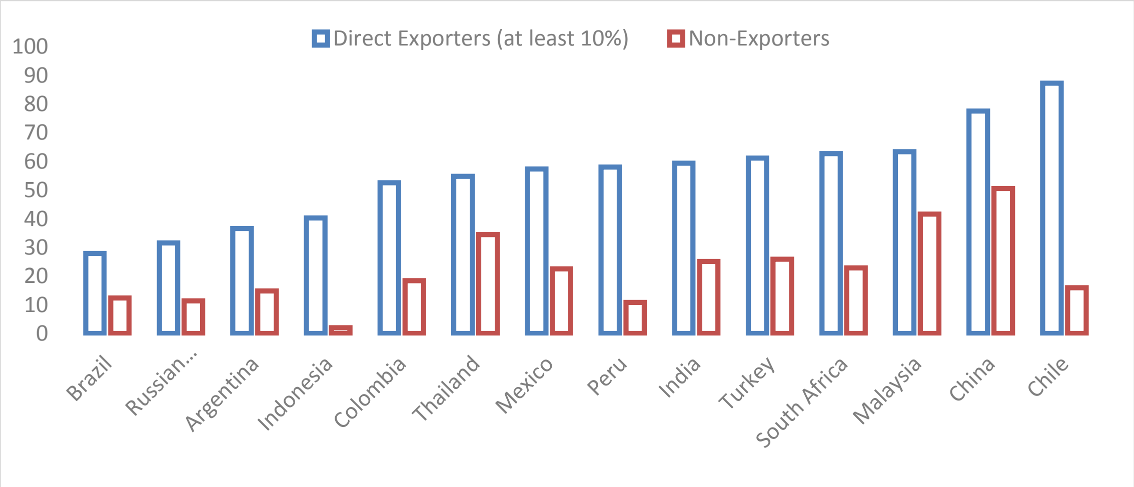
Figure 16: Percent of firms having annual financial statements reviewed by external auditor, selected countries. Various years



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.

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. By alleviating asymmetric information failures –signaling to external parties that the firm is a high-performer on quality management issues– quality certification is a form of upgrading that facilitates firms' integration into global value chains (GVCs) and exporting.[10] Certification facilitates firm growth (after certification) and the growth effect is greater when buyers have greater difficulty acquiring information about suppliers.[11] Although ISO certification is mainly procedural in nature, it is increasingly seen as a requirement for firms supplying high quality markets, and is therefore likely to reflect an emphasis on quality in production.

Figure 17: Percent of manufacturing firms with international quality certification by exporting status, selected countries. Various years

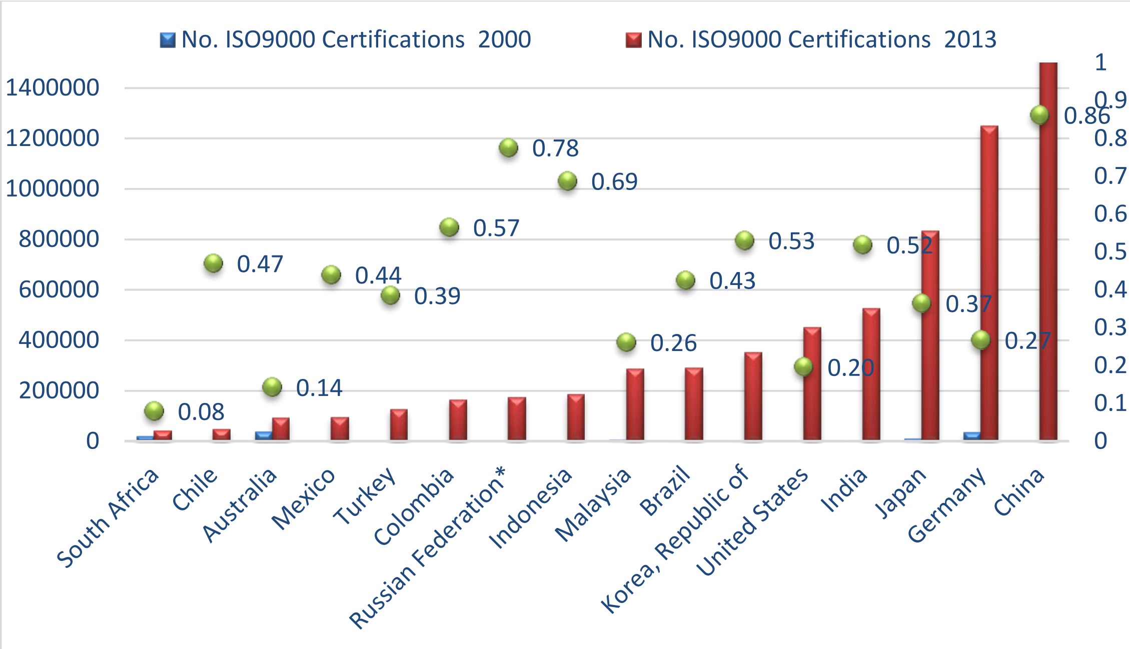


Source: World Bank Enterprises Survey, online database. Years of Survey: Brazil: 2009; Russian Federation: 2012; Indonesia: 2009; Thailand: 2006; India: 2014; Turkey: 2013; China: 2012.

In Brazil, only 26% of manufacturing firms have an international recognized quality certification while the corresponding figure for China is 53%. Firms that export are more prone to have international quality certifications than non-exporting firms (Figure 17): 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.[12] Adjusted by the size of manufacturing in the economy (Figure 18), 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 the number of ISO certificates issued to Chinese firms.

Figure 18: International Certifications ISO-9000 adjusted by the Share of Manufacturing in GDP and Average Annual Growth Rate -Selected Countries, 1993-2013

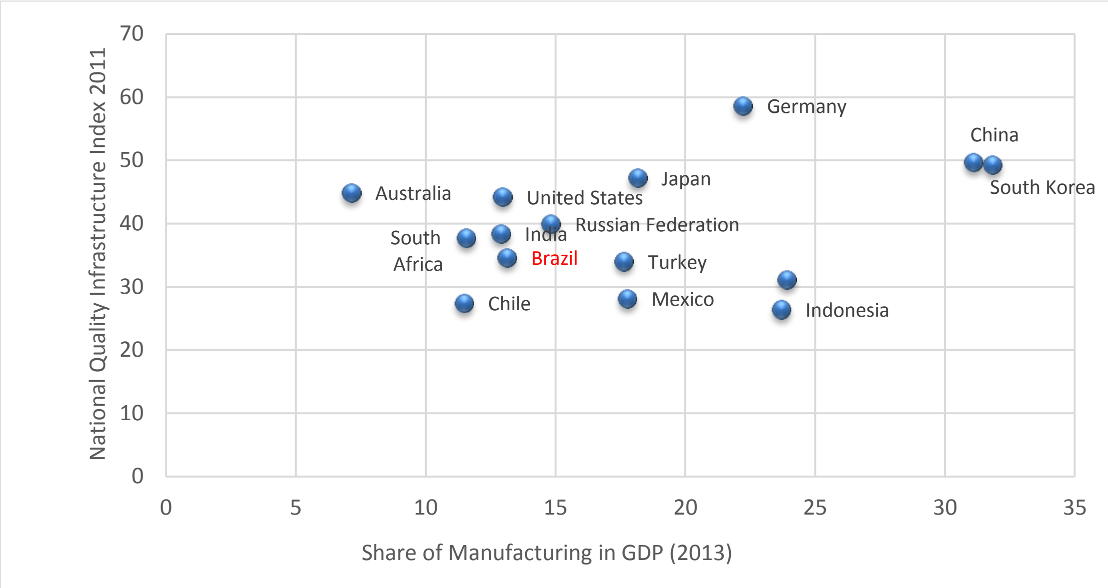


Source: Authors with data from ISO Survey 2013 and World Development Indicators (WDI).

A less-developed national quality infrastructure on the supply side; and a preponderant focus on less-competitive local rather than global markets on the demand side contribute to dissuading firms' adoption of international quality standards in Brazil. On the supply side, Brazil ranks 30th out of 53 countries in the Quality Infrastructure Index, adjusted by GDP.[13] 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.

That these services are not well developed 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, and thereby increase their productivity.

Figure 19: Quality Infrastructure Index (PTB-2011) and the Share of Manufacturing in GDP, selected countries. 2013

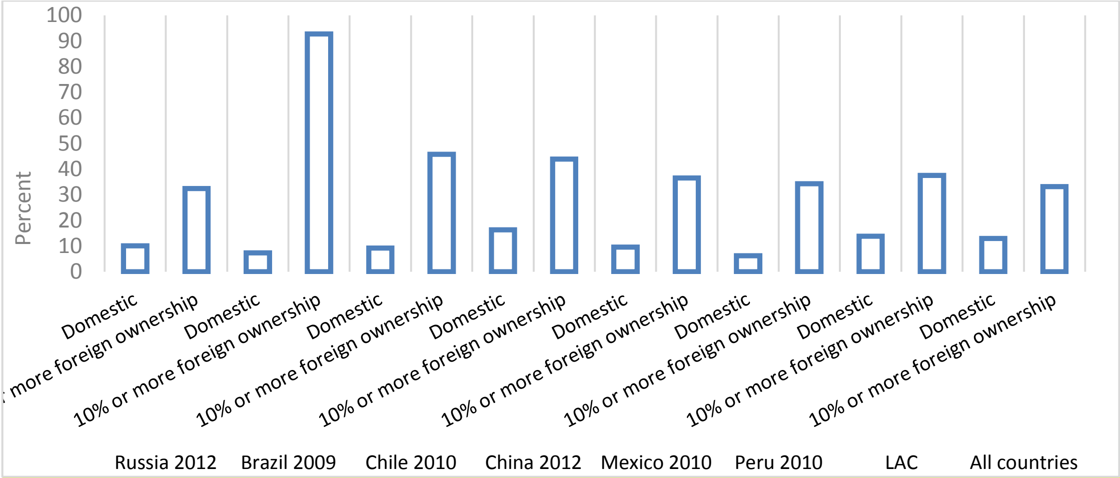


Source: Authors with data from Harmes-Liedtke and Oteiza Di Matteo (2011) and World Development Indicators (2014).

Firms in Brazil also exhibit less use of technology licensing from foreign companies. Only 7% of domestic firms in Brazil are engaged in technology licensing whereas firms with this type of technology adoption and learning transaction represent 16% of total firms in China, 10% in Russia and Mexico, and 13% on average for all countries (see Figure 20). On average, 14% 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.[14] 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 which is the most frequent type of innovation in firms in developing countries; internal R&D ("make") is mostly associated with product innovation.

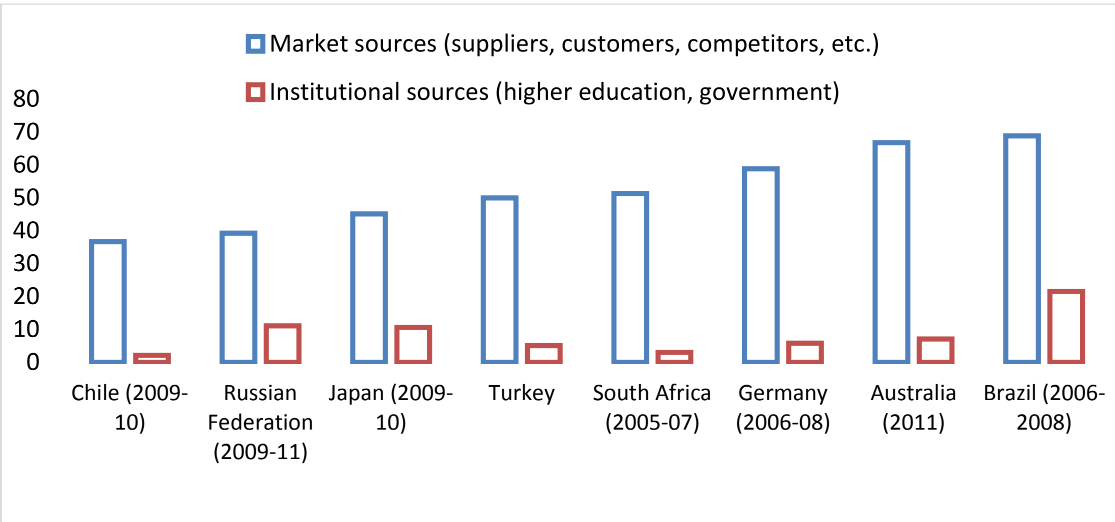
Figure 20: Percent of firms with technology licensing from foreign companies per ownership origin. Various years



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.

Brazilian businesses appear to highly value external sources of knowledge for innovation. Figure 21 conveys a message consistent with the prevalence of catch-up rather than frontier innovation. In line with other economies, Brazilian companies rely much more for the development of innovation on external market sources of information (from suppliers, customers, competitors, etc.) than institutional sources of a more basic scientific character (higher education and public-supported basic science). About 70% of innovating companies declare that market sources of information are highly important for their innovation while in South Africa, Russia or Turkey, this ratio is less than 50%. What remains unclear is the extent to which Brazilian firms remain even more constrained in accessing such knowledge, the underlying quality of accessed technologies, and the capacity of businesses to make most productive use of such knowledge.

Figure 21: External Sources of Knowledge for Innovation. Percentage of product and/or process innovative firms citing source as "highly important". Various years



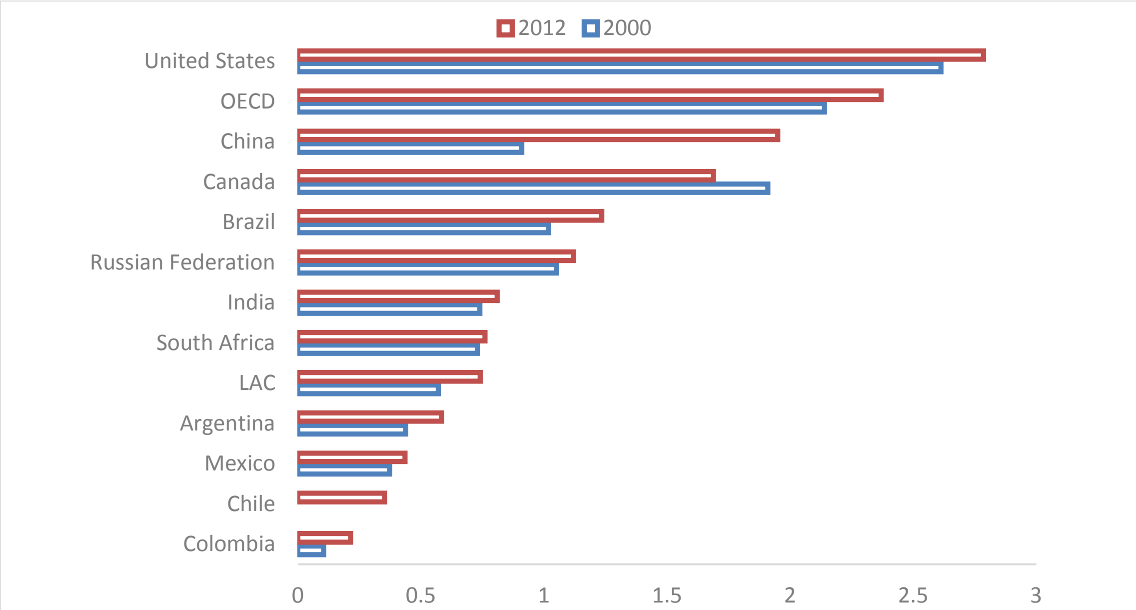
Source: OECD STI Scoreboard 2013.

1.2.2.Innovation and Industry-Science Collaboration

To remain competitive over the very long run, businesses ideally 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 eventually will require frontier innovation. External technology acquisition and frontier innovation both require a sufficiently developed "*absorptive capacity*" and enabling "*social capabilities*".[15] Cultivating this capacity for better absorbing technologies eases the process of catch-up by facilitating the search for external technologies, their absorption, and their adaptation to local context.[16] More generally, 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 European and OECD comparators. Brazilian investment in R&D has increased from 1.01% of GDP in 2000 to 1.23% in 2012 (Figure 22), and 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% 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% and 2.5% of GDP, respectively (Figure 23).

Figure 22: R&D as percent of GDP



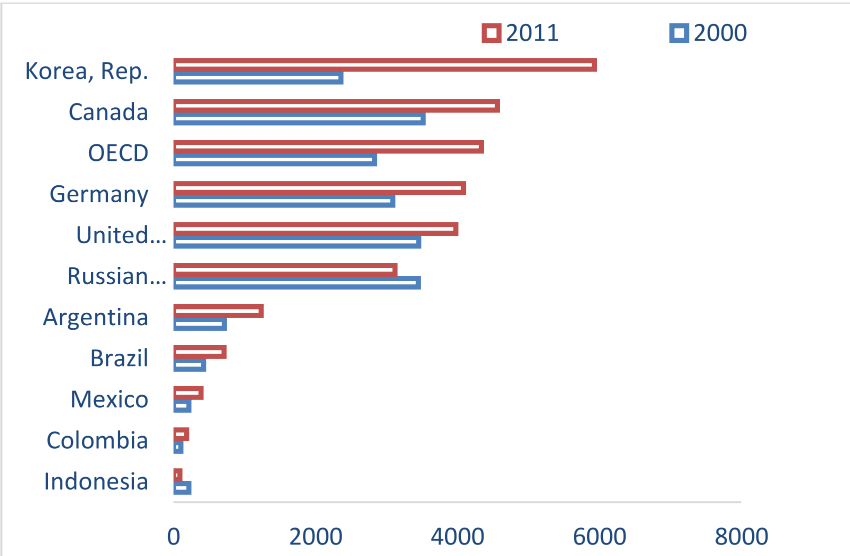
Source: OECD STI Scoreboard (2014), World Bank Development Indicators 2014 and RICYT (Red de Indicadores en Ciencia y Tecnología).

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% to 0.61% 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.

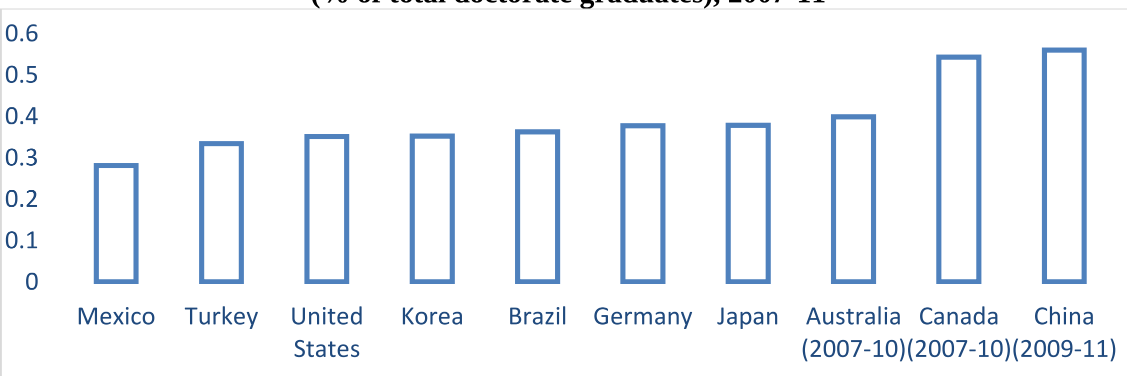
The number of PhD researchers per 100,000 residents more than doubled between 2000 and 2008, expanding from 17 to 40. The share of science and engineering (S&E) PhDs also improved: over the period 2007-2011, Brazil's share of S&E doctorates in total PhDs is now similar to leading economies such as Japan, Germany or South Korea (Figure 24). However, most of researchers remain working in the public non-business sector and only a few join the business sector. Several deficiencies remain indicating that research excellence standards only concern a handful of institutions.

Figure 23: Researchers per Million People



Source: OECD STI Scoreboard (2014), World Bank Development Indicators 2014 and RICYT (Red de Indicadores en Ciencia y Tecnología).

Figure 24: New doctorates in science and engineering (% of total doctorate graduates), 2007-11



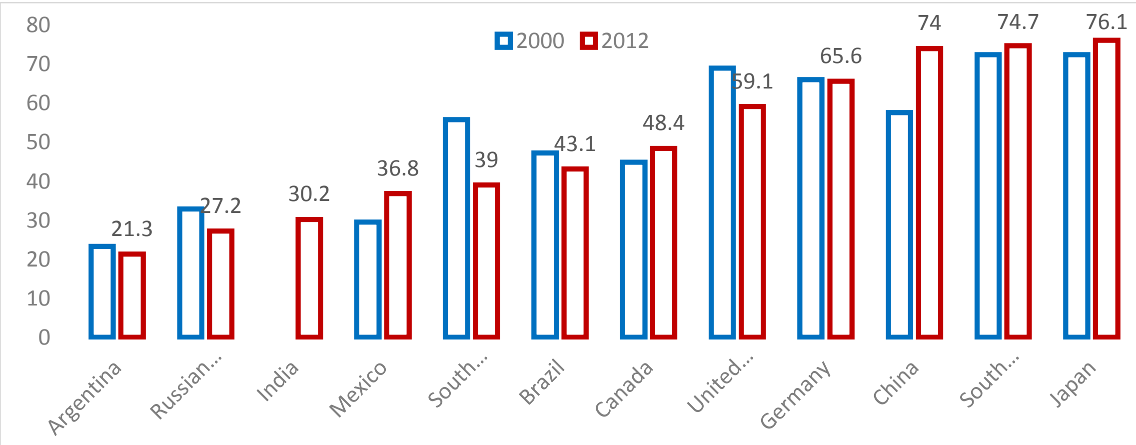
Source: OECD Science, Technology and Industry Scoreboard 2013.

And 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%. 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% (Figure 25) whereas the government share increased from 53 to 56.9%. In 2012, R&D financed by the business sector represented 0.53% of GDP, a third of the corresponding OECD average at 1.59% (OECD, 2013).

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.[17] 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 and 41% more respectively on innovation. Brazilian businesses could be investing more in innovation given Brazil's accumulation of factors of production.

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.[18] 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 *et al*, 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.

Figure 25: Share of the Business Sector in the Financing of National R&D Investment, 2000 and 2012



Source: World Bank Development Indicators, UNESCO and MCTI (Brazil).

Several additional factors have hindered the contribution of public S&T and R&D to economy-wide innovation and productivity. They include: (1) a disconnect between S&T investments from business needs and demands, (2) a too slow shift by researchers from theoretical to more practical applications, (3) regulatory and governance deficiencies that constrain business collaboration, and (4) a continued scarcity of engineering and technology specialists.

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% of researchers are working in universities while in Germany 65% and in the US 75% 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% in 2000 to 20% in 2010.[19]

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% of researchers in Japan and about 65% in Russia and South Korea are in the fields of engineering and technology, only 20% of total researchers belong to engineering and technology (UNESCO, 2011). Overall, only 6% of researchers in the Brazilian educational system are dedicating 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.

The quality of research and higher education is also challenged. 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 band.

Overall, the Brazilian innovation ecosystem and its performance are yet immature as insufficient articulation prevails amongst its parts, particularly between research and technology institutions on one side, 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. 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.

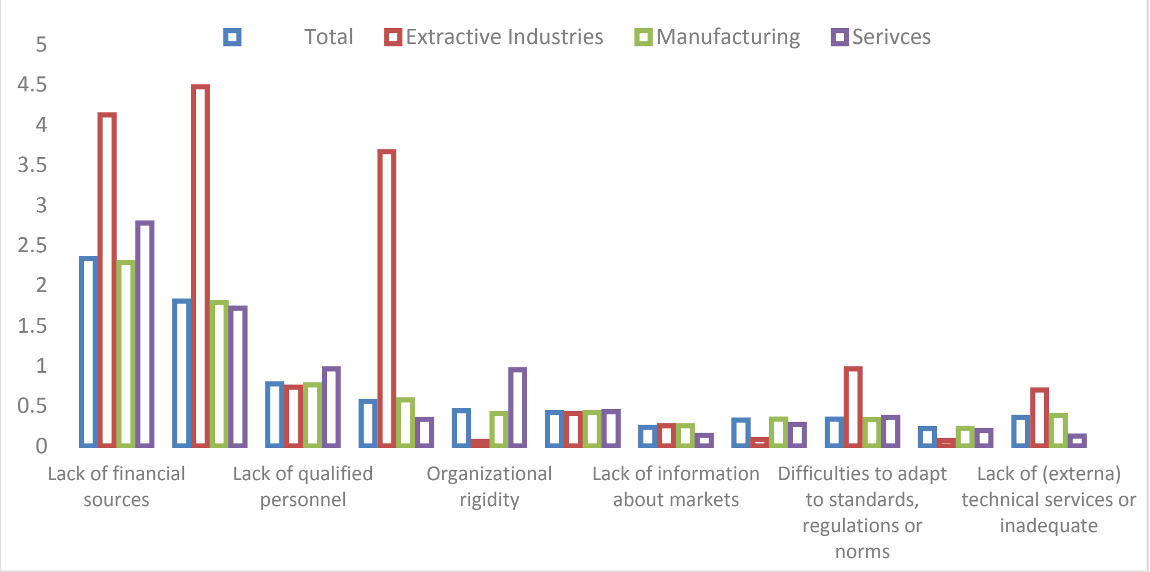
2. Constraints to Firm Innovation

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 polices as well as insufficient articulation 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 (Figure 26), 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 (sources of knowledge) for innovation.[20]

Figure 26: Obstacles to Innovate in Brazilian Firms (% of firms declaring such obstacle as very important in the total of innovating firms), 2011.



Source: PINTEC 2011 (IBGE).

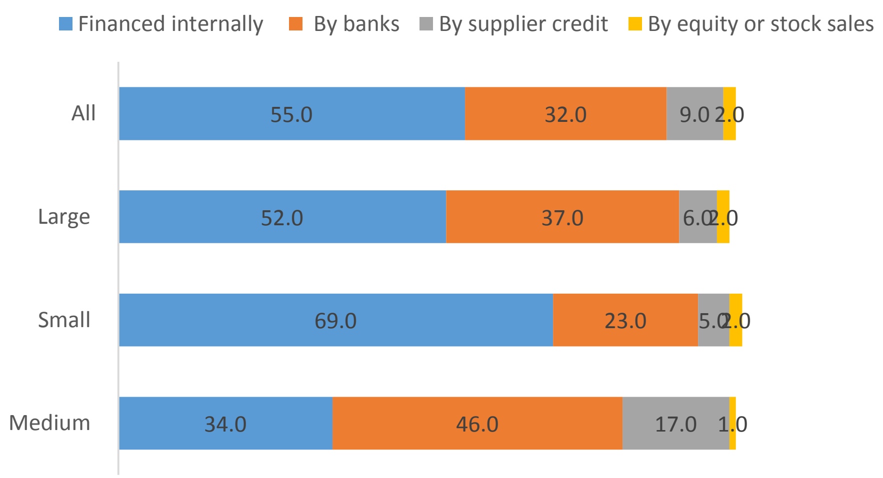
2.1. Financial Constraints

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 (Figure 43).

Financial frictions 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.[21] Furthermore, this negative effect is amplified as financial constraints force export and innovation activities to become substitutes although they are generally natural complements.[22] The difficulties in accessing finance for innovation include its high uncertainty and the appropriable nature of ideas (exacerbated by weak intellectual property protection).

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% by banks), compared to 34 percent of investments of medium firms (46% by banks), and 52 percent of investments of large firms (37% by banks) (Figure 27).

Figure 27: Brazil: Share of Investments Financed by Various Sources



Source: World Bank Enterprise Survey.

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.[23]

The legal framework for secured transactions has not been modernized, and there is no unified electronic movable collateral registry. Issues with regards 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.[24] 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% as of 2014 – low compared to PE leaders such as Israel (1.64%), the US (1.23%), the UK (0.81%); but in line with emerging market comparators such as India (0.19%); China (0.15%); and South Korea (0.18%). Assets under management held by PE funds in Brazil amounted to $43bn at the end of 2013.[25]

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.

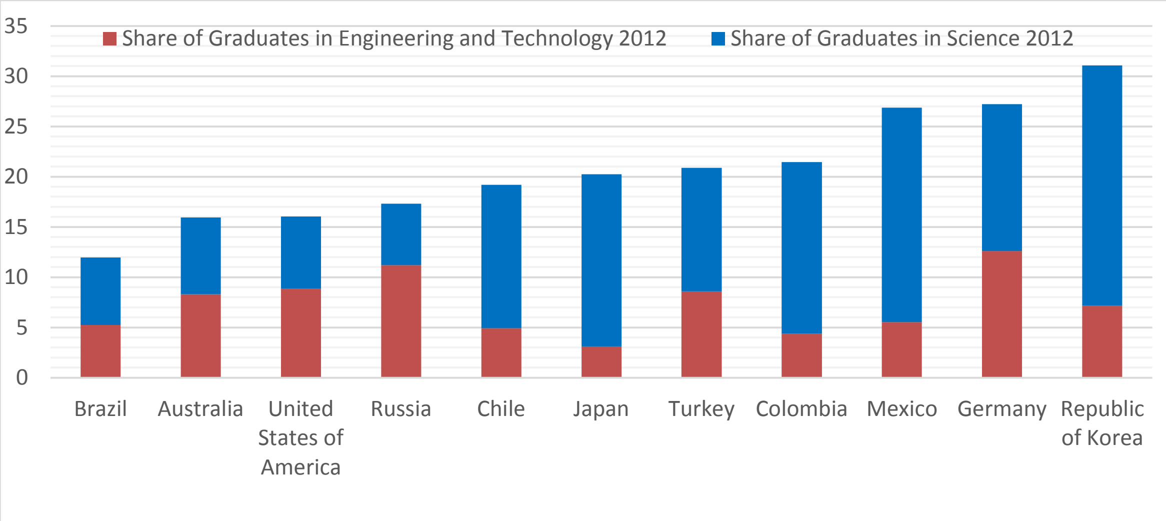
2.2. Human Capital

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 Outlook 2014). Not only the quantity but also the quality of education needs to be reinforced at all levels, with participation of business 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. Figure 28 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 5.25% of total university graduates whereas in Germany and Finland around 13% and 20% of university graduates come from engineering-related fields (Engenheria Data, 2014). 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 density of engineers in the labor force has played a significant differentiating role in helping economies move to higher income levels.[26]

The development of skills in Brazil, especially in S&T, is further hindered by a weaker international mobility of students. Brazil is characterized by lower rates of international mobility of both graduate and undergraduate students compared to peer economies (Figures 29 and 30). 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.[27] 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. Brazil has recently taken steps to improve this situation with the launch of the "Scientific Mobility Program" in 2011.

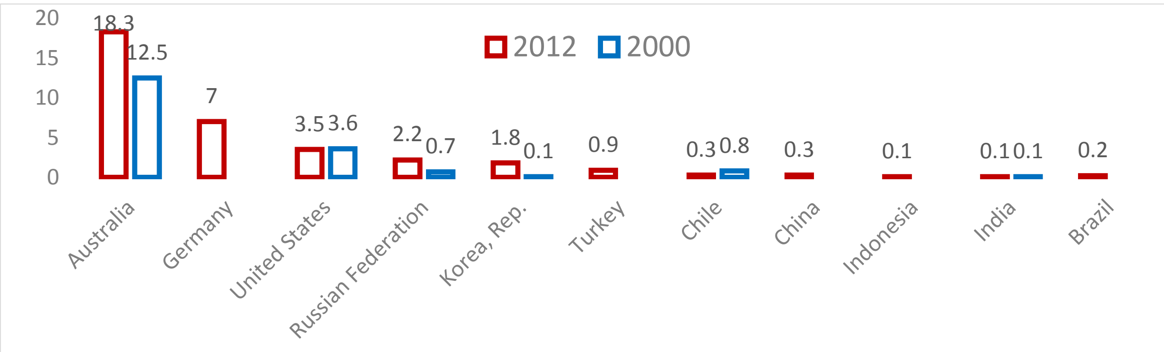
Figure 28: Graduates in Engineering (Technology, Manufacturing and Construction) and Science (% of total tertiary)- Selected countries, 2012



Source: UNESCO Institute for Statistics Online Database 2015. Data for Australia corresponds to 2011.

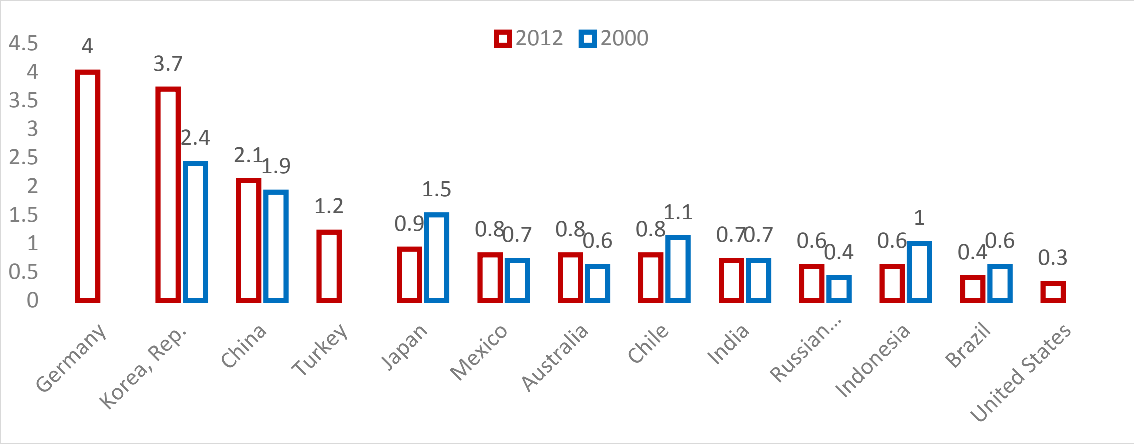
Brazil is strengthening efforts to address the issue of skills development and labor qualifications, notably through the PRONATEC program and under the umbrella of the "*Plan Maior*". A key challenge facing PRONATEC is to improve partnerships with business. PRONATEC needs to improve partnerships with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

Figure 29: Inbound Mobility Ratio in Tertiary Education



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. 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.

Figure 30: Outbound Mobility Ration in Tertiary Education



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. 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.

2.3. Regulatory Framework

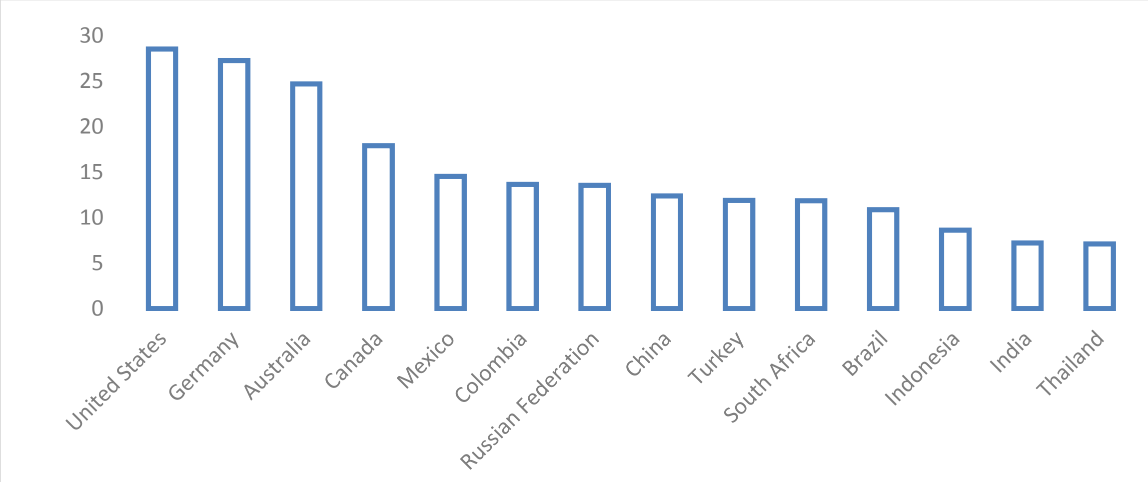
2.3.1 Business Regulatory Framework

In terms of regulatory framework (framework conditions) for innovation, Brazil shows lower levels of development in Intellectual Property Rights (IPR) Protection and in several areas of the regulatory framework for business development.

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 Intellectual Property Rights (IPR) protection than comparators such as Mexico, Colombia, Russia, China, Turkey and South Africa (Figure 31). 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.

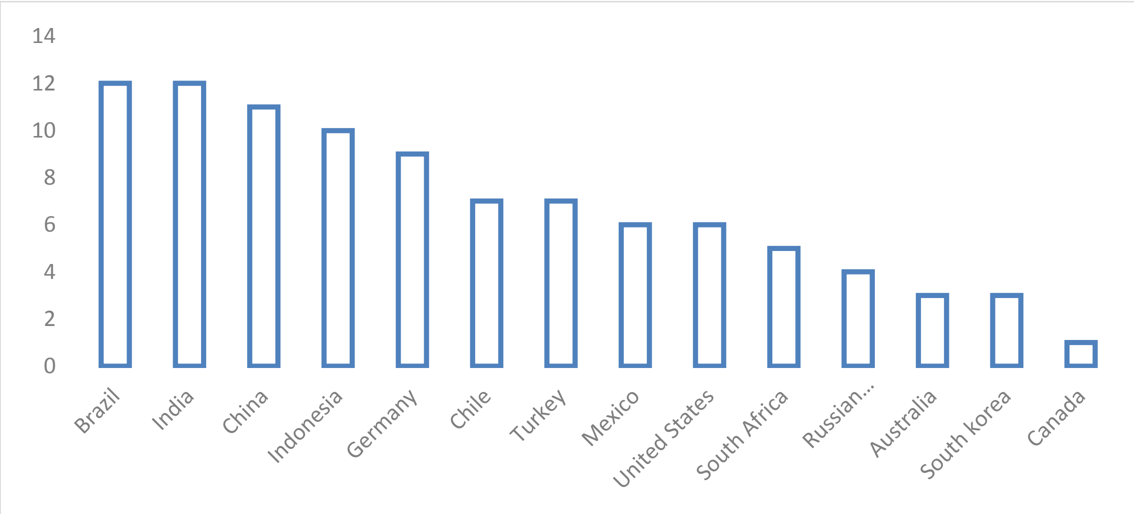
Improving the IPR legal framework and functioning is important for innovation and business development particularly for countries moving up in the development cycle and starting to invest in frontier innovation capacity.[28] As economies develop and acquire valuable knowledge assets, local firms begin to develop a vested interest in building IPR institutions and protecting intellectual creations to foster competitiveness.[29] An effective IPR system is also ancillary in the development and organization of markets by helping consumers scrutinize quality of products and services and their origin e.g. signaling quality of a brand is the main attribute of trademarks, origin designations, and geographic indications.

Figure 31: International Intellectual Property Index 2014



Source: Global Intellectual Property Center (GIPC)- International Intellectual Property Index.[30]

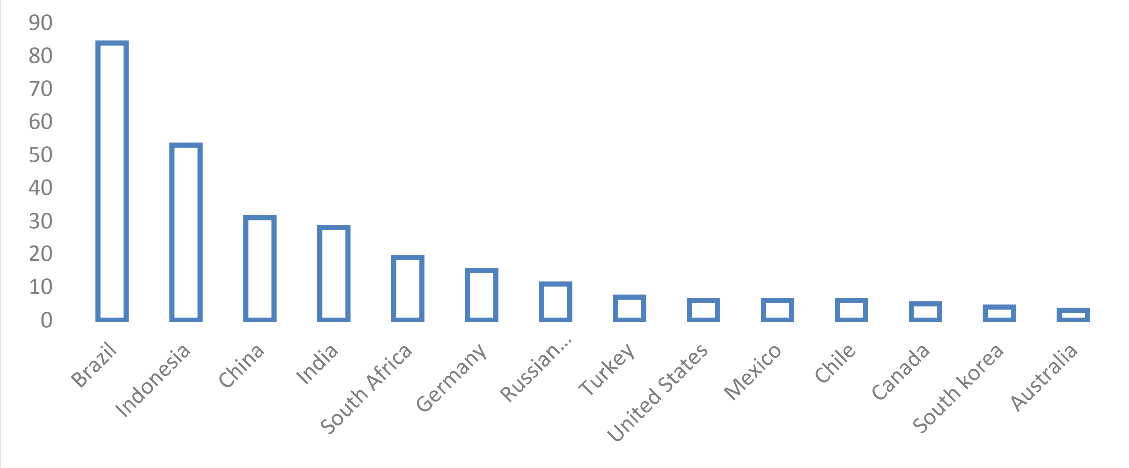
Figure 32: Number of procedures to register a new business in 2014



Source: World Development Indicators, World Bank.

Brazil trails substantially behind peer economies in several dimensions of the regulatory business environment for firm creation. In 2014, jointly with India, the number of procedures to register a new business was the highest among the BRIC economies and this number was seven times larger than Canada and five times larger than 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 80 days to open a new business in Brazil while in the US, Mexico or Canada it takes less than 10 days (see Figures 32 and 33).

Figure 33: Number of days to register a new business in 2014

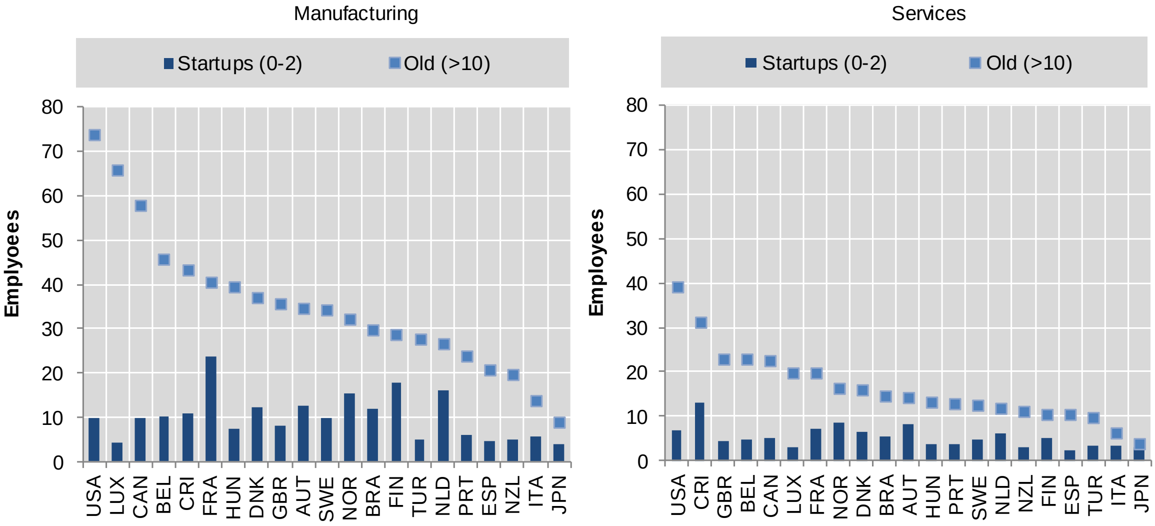


Source: World Development Indicators, World Bank.

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 underpins 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 favour 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% 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 (Figure 34), and their small size limits their impact on innovation, the economy and society. Policies which (unwittingly) 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.

Figure 34: The average size of start-ups and old firms



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.*Source*: Criscuolo, Gal and Menon (2014) and OECD DynEmp Express Database, April 2015, www.oecd.org/sti/dynemp.htm

Trade regulation is another policy area with implications for innovation, with restrictions to trade having expanding 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 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, 2014). Tariffs are not only high on final products, but also on intermediate and capital goods, which are becoming increasingly important in a globalized world. Figures 35 and 36 show that Brazil has the highest average tariff on both intermediate and capital goods, in comparison to other developing, emerging and advanced benchmark economies. 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%).

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 cited in 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.[31]

Figure 36: Average tariff on capital goods, 2013 (%)

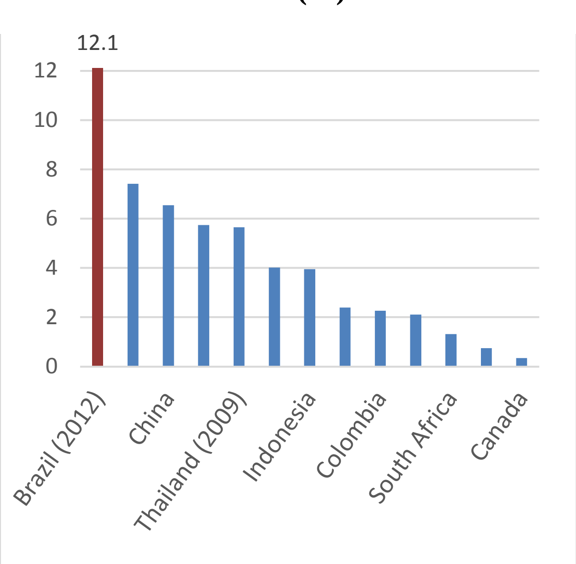
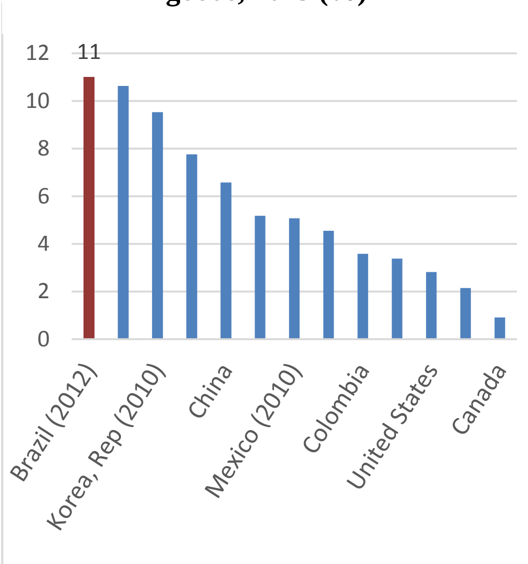


Figure 35: Average tariff on intermediate goods, 2013 (%)



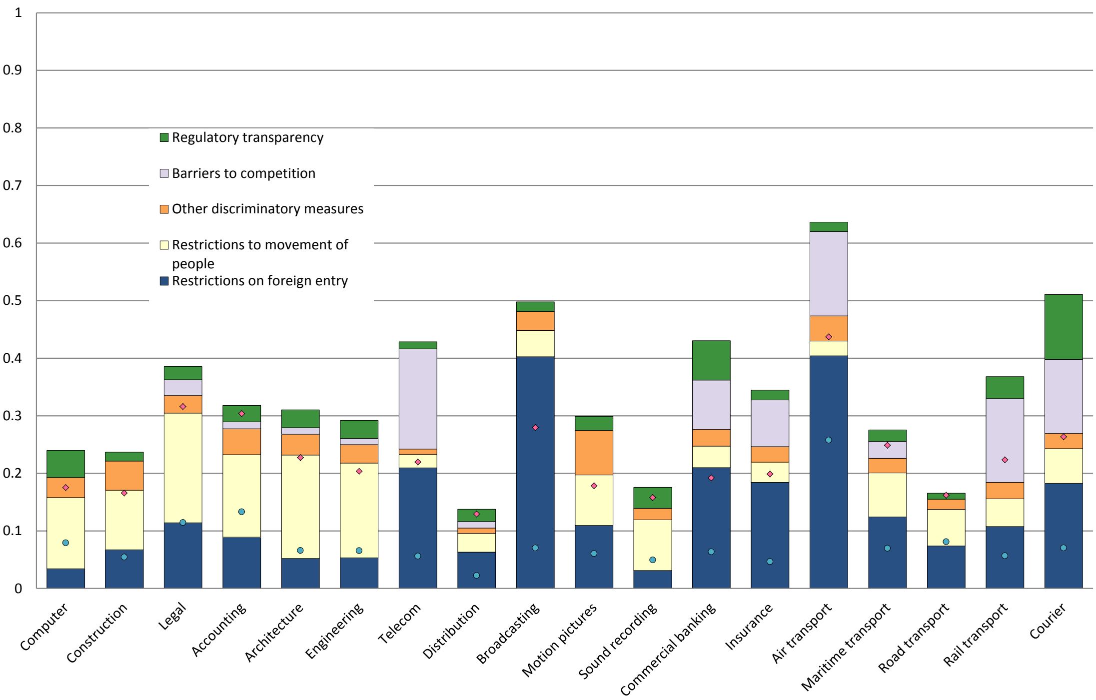
Source: World Bank, WITS
Note: Years vary based on data availability

Despite progress, in particular 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 (Global Competitiveness Report 2014-2015) (Figures 37 and 38).

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. The OECD Services Trade Restrictiveness Index points to several sectors where regulations particularly affect services trade (Figure 36). 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 13 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 labour 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.

Services account for only 14% of Brazil's gross exports, but much more in value added terms, 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.

Figure 36: Services Trade Restrictiveness Index for Brazil



Source: OECD (2014), http://www.oecd.org/trade/services-trade-restrictiveness-index.htm

Barriers to entry and rivalry remain the main source of restrictiveness in the Brazilian regulatory framework. According to OECD's Product Market Regulations, barriers to entry and rivalry increased from 2008 to 2012. 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.

Figure 37: Effectiveness of anti-monopoly policy 2014-2015 (7=most)

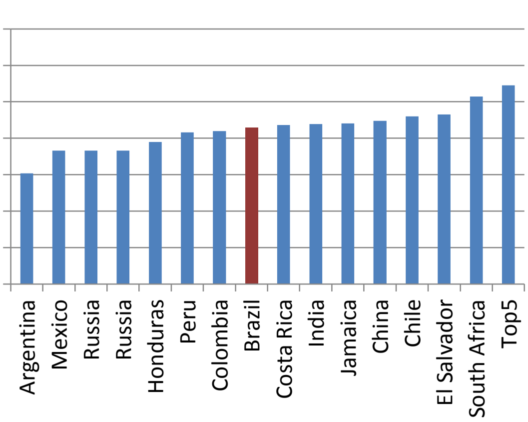
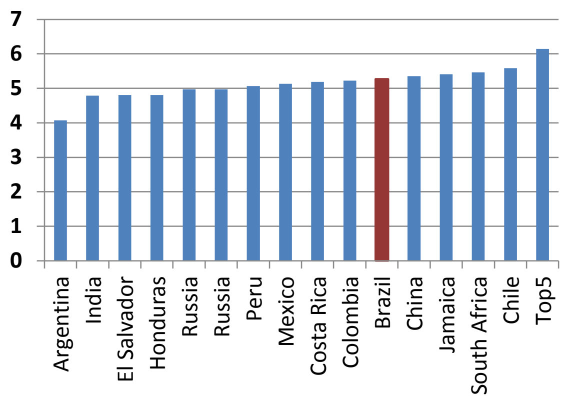


Figure 38: Intensity of local competition 2014-2015 (7=most)



Source: WEF, Global Competitiveness Report 2014-2015,
Tote: Top 5 refer to best performing countries in GCR for each indicator.

2.3.1 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.

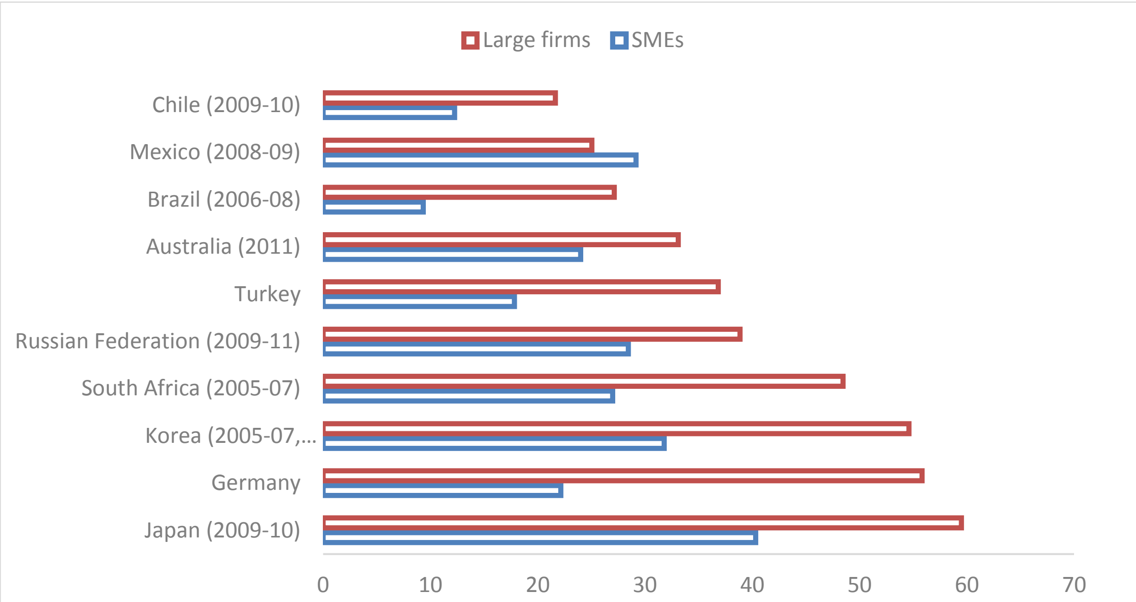
New reforms are under discussion at the Congress with the creation of new Science, Technology and Innovation Legal Code (Law Project n°2177/2011). This code aims to make more effective the collaboration between public institutions and private firms, as well to use the purchasing power of the government to foster innovation. The use of Public Procurement for Innovation (PPI) is constrained in the current Brazilian legal framework for public procurement. There appears to exist a mindset against cooperation and risk taking involving intangible assets in public and private expenditures.

2.4. 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 countries (Figures 39 and 40). 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 located abroad. Collaboration in innovation can have important benefits for firms.

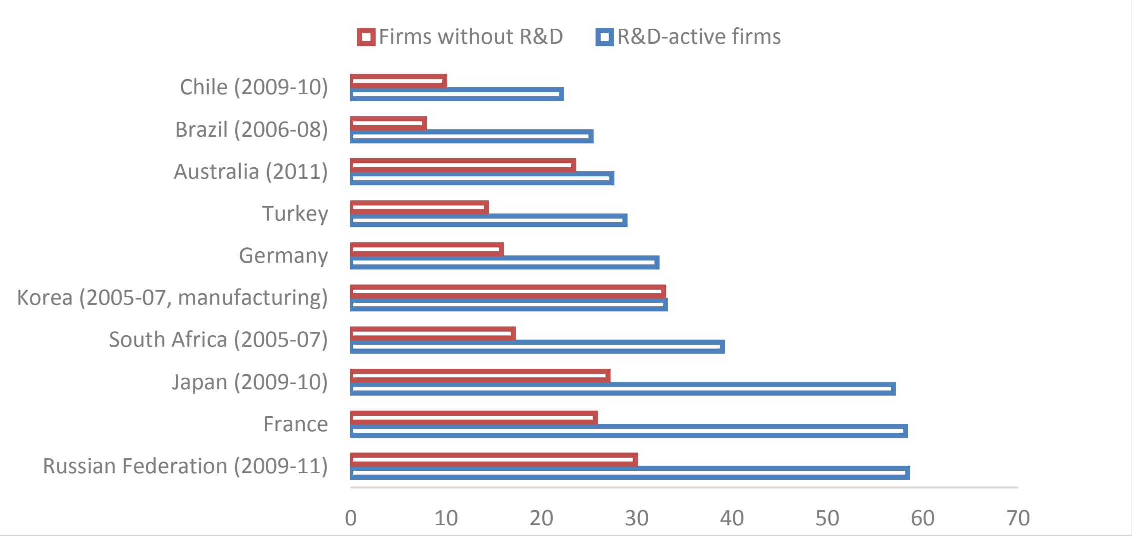
Cooperation activities in principle can help businesses access complementary technological resources (such as skill sharing) and reduce costs, and thereby develop economies of scale and scope.[32] Cooperation with other firms, particularly with clients and suppliers, is frequently associated with increased innovation performance and productivity gains.[33] 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. [34]

Figure 39: Co-operation in innovation with other firms or institutions by size (innovative companies). Various years



Source: OECD Industry, Science and Technology Scoreboard (2014)

Figure 40: Co-operation in innovation with other firms or institutions by R&D status (innovative companies). Various years



Source: OECD Industry, Science and Technology Scoreboard (2014)

3. 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 Nº. 10,973, of December 2004) and the "Lei do Bem" (Law Nº. 11,196, of November 2005).

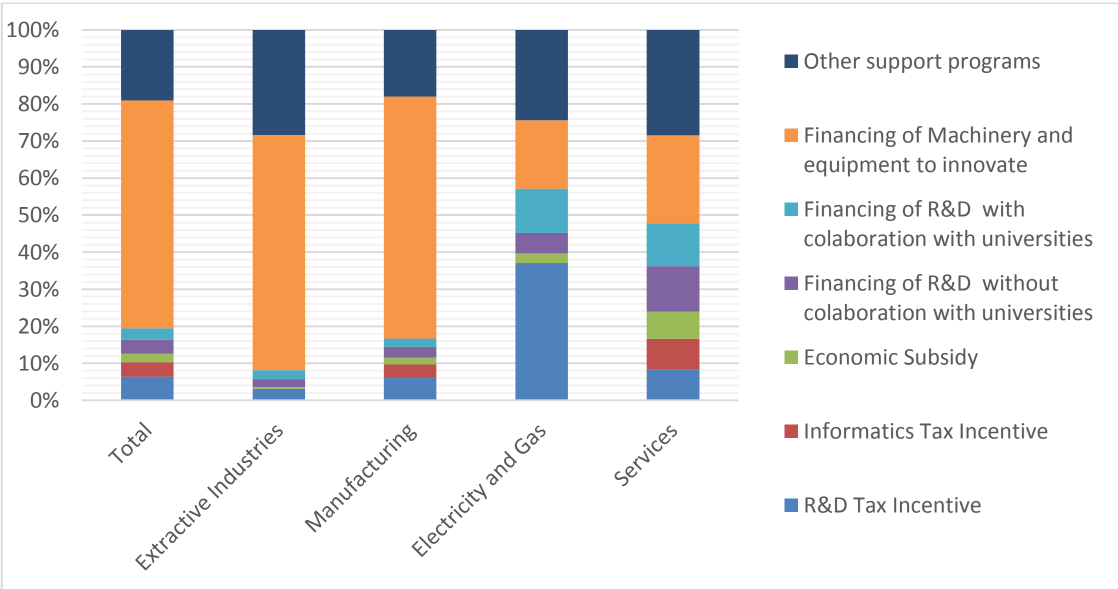
The Innovation Law provided rules for intellectual property creation and commercialization at public research institutions and facilitated collaboration between universities and private businesses. The law encouraged the public and private sectors to share staff, funding, and facilities, and has allowed 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 made it easier to use indirect tax incentives for private R&D investments 9such tax incentives were originally introduced in the 1990s). It also enabled 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*" (Biggest Brazil) 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.

Overall, both financing and the legal framework for innovation have been improving substantially, with promising initial results. The first clear result of these improvements is the increase in the number of innovative firms that had some sort of public support to innovate. In 2003, only 19% of innovative firms declared that they had governmental support to innovate. This number increased to 34% in 2011 (Figure 41). Although all kinds of public support have increased in the latest years, most of them are related to financing machinery and equipment to innovate: roughly 75% 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)[35].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% to 8.6% of innovative firms between 2003 and 2011.

Figure 41: Enterprises that received government support for innovation activities by type of support–within innovating firms for the period 2009-2011



Source: PINTEC 2010-2011 (IBGE).

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 evaluation 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.

3.1. 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.

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[36] 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 Reais – mi)
Tax Breaks	Tax exemption created for companies who invest in R&D, created by Law Nº 11,196/2005 (“Lei do Bem”)	1,476.8
	Tax exemption for companies in the ICT sector, created by Law Nº 8.248/1991 and Nº 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 (approximate values)	~ 300.0
	The National Petroleum Agency (ANP) R&D program	1,226.7
	TOTAL	**1,526.7**

Sources: Ministry of Science, Technology and Innovation (MCTI) - ww.mcti.gov.br/indicadores; National Bank for Social and Economic Development (BNDES) - Annual Report/ 2013; Brazilian

Innovation Agency (FINEP); Electricity Regulatory Agency (ANEEL); The National Petroleum Agency (ANP) – Statistical Yearbook/2013.

3.2. 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. According to estimates by OECD, the amount of fiscal incentives for R&D represents 0.05% of the Brazilian GDP in 2013 while direct incentives (funding of BERD) represented 0.10 percent (OECD, 2015; Figure 43). In these indicators, Brazil stands high far above several OECD and other developing countries reported. Figure 42 shows the evolution of tax breaks for innovation in Brazil since 2000 and the percentage of GDP of these exemptions.

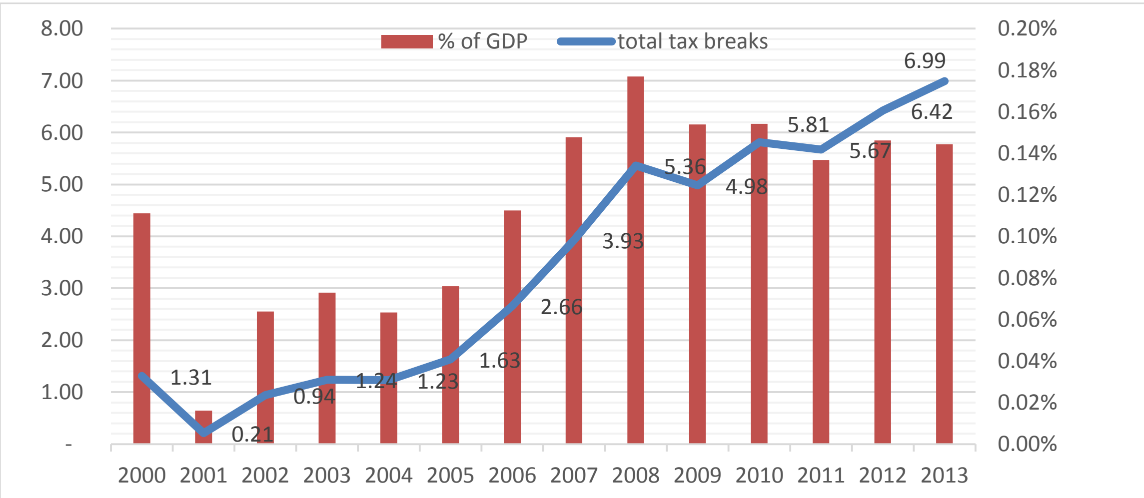
Box 1: Fiscal Incentives for Innovation in Brazil

Law 11,196 was enacted in 2005 to reinforce changes instituted by the Innovation Law. It was replaced in 2007 by Law 11,487, which became known as the "Fiscal Incentives Law" (Lei do Bem). This Law speeded 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% and 100%), reductions in the tax on industrial products for purchasing machines and equipment for R&D (50%), 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% of the salary in the North East and Amazon regions and 40% in the rest of the country for up to three years.

Source: Rocha (2013).

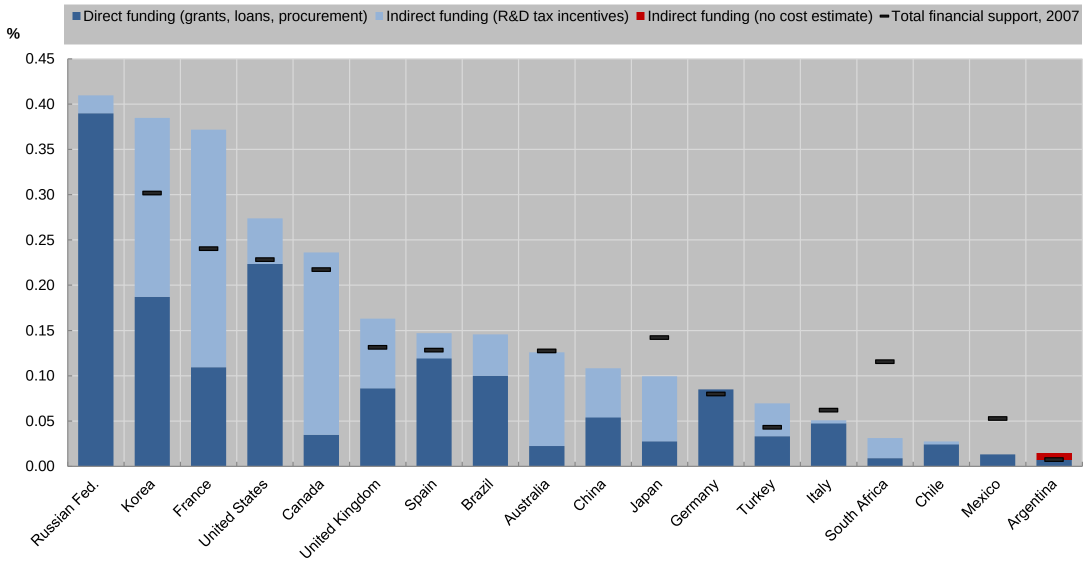
Figure 42: Total tax breaks in Brazil (R$ Billion and percentage of GDP): 2000-2013



Source: MCTI (www.mct.gov.br/indicadores) and IBGE.

The most important tax exemption is that 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 Nº 8.,48/1991 and Law Nº 10,176/2001). The law establishes some basic production requirements that need to be followed to enable firms to receive the tax reduction.

Figure 43: Public Policy for R&D –Indirect and Direct Funding of Business R&D as percentage of GDP, 2012 and 2007



Source: OECD (2015): OECD R&D Tax Incentive Indicators, www.oecd.org/sti/rd-tax-stats.htm and OECD, National Accounts and Main Science and Technology Indicators, 15 December 2014. Direct funding estimates for Brazil based on national sources.

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% of beneficiary firms had less than 99 employees. However, since the tax incentive focuses on the production tax (tax over industrialized products), 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 500 employees.

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 (R$)	Number of beneficiary firms
Less than 30 employees	40.995.961,74	108
30 to 99	149.420.106,95	122
100 to 249	238.641.019,78	65
250 to 499	245.257.027,44	27
More then 500	2.896.450.273,41	45
Total	**3.570.764.389,32**	**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 (see 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 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% 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).

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 (R$ mi)	R&D investment (R$ mi)	Exemption over investment in R&D
2006	130	229.0	2109.4	11%
2007	300	883.9	5107.8	17%
2008	460	1582.7	8804.1	18%
2009	542	1382.8	8331.2	17%
2010	639	1727.1	8622.0	20%

Sources: Evaluation and Monitoring Advisory (ASCAV), Ministry of Science, Technology and Innovation (MCTI) and 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".

In spite of the small number of companies, the R&D investments by the beneficiary firms in 2010 (R$8.6 bn) represent more than 40% 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).

Table 5 - 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.

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, are responsible for more than 80% 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.

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 favour 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 favouring 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.

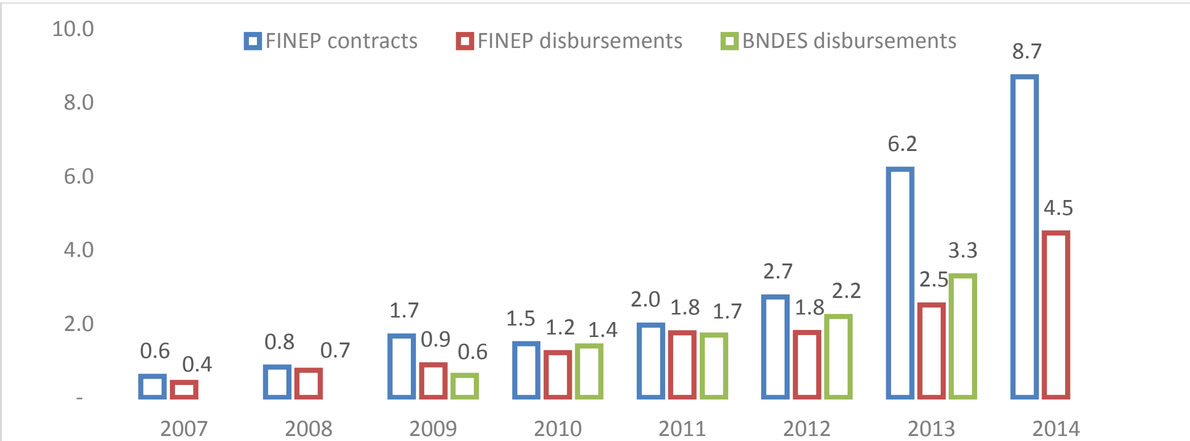
For the reasons outlined above, grants and other forms of direct support may be valuable as a complementary form of support for R&D, perhaps targeting the firms that are unlikely to benefit as much from tax incentives (e.g. young firms). In other cases it may be necessary to provide direct forms of support 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.

3.3. 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 (Figure 34)[37].

Within FINEP's budget until 2010, the largest share (R$1.1 billion) was the National Fund for Scientific and Technological Development (FNDCT), which is targeted at research infrastructure and academic research, mainly in universities (Figure 35). 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% in 2014.

Figure 44: Credit for innovation in Brazil in BNDES (disbursements) and FINEP (disbursements and contracts): 2007-2014 (R$ bi).



Sources: National Bank for Social and Economic Development (BNDES) - Annual Report/ 2013; Brazilian Innovation Agency (FINEP).

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% of total BNDES disbursements).

In 2010, FINEP's credit portfolio reached around 140 companies, most of them (around 66% of the firms) in manufacturing industries. Regarding firm size, most of the loan resources (63%) have been oriented to large companies, which are almost a half of all beneficiaries (Table 6).

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% 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[38]. 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.

Table 6 - Total value of loans by FINEP in 2010 and number of beneficiary firms, by size.

Size of firm	Number of firms	%	R$ Billion	%
Less than 30 employees	17	12%	30.951	3%
30 to 99	15	11%	83.837	7%
100 to 249	24	17%	89.992	7%
250 to 499	19	13%	236.482	19%
More then 500	67	47%	768.866	63%
Unknow	1	-	7.982	-
Total	142	100%	1.218.110	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 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% less productive than large firms, and medium sized firms are 15% less productive than large firms.[39] 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.[40] 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.[41]

3.4. 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.[42] Around 40% of this S&T public investment was targeted at maintaining post-graduate university courses and institutions (at both the federal and state levels).

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 7 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 (see Mowery 2009). The Ministry of Science, Technology and Innovation is responsible for the biggest share (36%) 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)[43]. 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[44].

The Ministry of Agriculture (MAPA) invested around R$ 2.4 billion in S&T in 2012, that is around 13% 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.

Table 7 - Federal S&T investments in Brazil in 2012 (excluding post-grad investments)

MINISTRIES	R$ 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

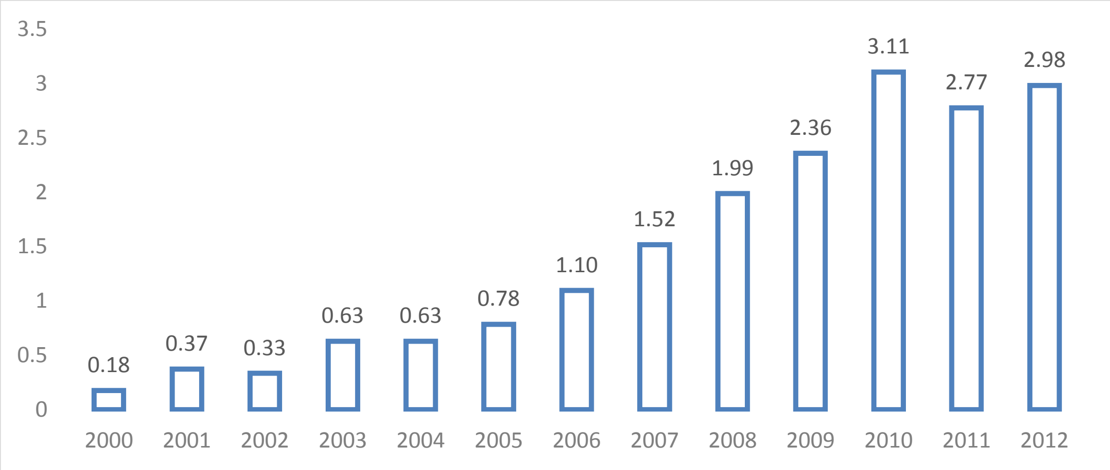
Source: MCTI (www.mct.gov.br/indicadores - several tables).

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. Figure 45 shows the evolution of FNDCT’s budget execution since the creation of the Sectoral Funds until 2012.

Figure 45: FNDCT's total budget execution: 2000 to 2012 (R$ bi).



Source: MCTI (www.mct.gov.br/indicadores - table 2.2.5)

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 8).

Table 8 – FNDCT's Budget breakdown: 2013

	RS MI
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.

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% 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% 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,[45] 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.[46] Therefore, the overall budget of MCTI remained stable compared to other areas of the Government over recent years.[47]

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 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).

3.5. Technology Extension

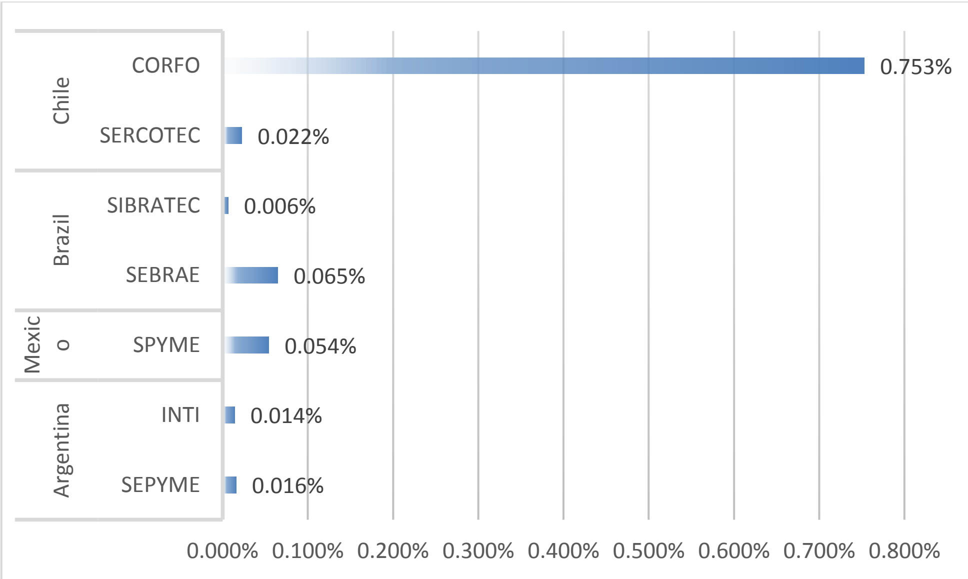
Brazil has an important network of public and private providers of technology extension services for SMEs. These include SEBRAE, SIBRATEC, SENAI, and regional development agencies. These provide support ranging from training for technology adoption and managerial skills, facilitating information (about 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% of GDP (Figure 79), relative to about 0.07% of GDP allocated to SEBRAE and SIBRATEC, the main agencies for technology extension.

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.[48] In collaboration with FINEP, SEBRAE also finances innovation projects in micro and small enterprises belonging to *Aranjaos 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 (MCT, 2010) (see Box 3).

Figure 46: Public Support to Technology Extension (SMEs) in selected LAC countries as percent of GDP (2012)



Source: Andes, Ezell and Leal (2013), ITFI.

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.[49] 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 USD135 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.[50]

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 Brasilia. 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.

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 18 technological services networks involving 54 institutions and 527 laboratories. Sibratec is made of three types of network: 1) 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; 2) 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 3) 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) and Elizabeth Balbachevsky and Antonio Botelho (2013).

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; 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.[51]

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[52]), 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.

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).

3.6 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* (Geater 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%), IT and telecom (13%) and retail (9%) and 47% of B2B (business-to-business) are supported, namely projects focusing on solutions for companies.

4. 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 depending on primary industries. Brazil is at cross-roads and needs to generate new sources of growth based on knowledge and innovation, competencies that drive global competitiveness. In doing so, Brazil has the challenge of expanding social achievements of the last decade and creating a more inclusive growth with enhanced opportunities for employment and income growth nationwide.

This diagnostic and policy review exposes 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 innovation performance. With the exception of few strategic industries, expanded S&T competencies, including improved scientific performance and infrastructure, training and new human resources have not yet been translated or reflected in a superior national innovation performance, particularly in the business sector.

Second, the current situation in the private sector indicates a trailing in innovation activities by Brazilian firms: R&D intensity of investment and technology adoption rates (of both hard and soft technologies) are lower than peers 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; 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?

Public policies for innovation have not been missing in Brazil. On the contrary, public support to science, technology and innovation has been expanded substantially, with steady increases in public funding and a multiplication of policy instruments and programs. In fact, the levels of public support to innovation (particularly to R&D activities) as 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.

In spite of steady increases in public support to 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 taking place in the public sector) are at least eight times larger than the resources deployed for 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 firms. Overall, opportunities for innovation remain weak in spite of a large market and improved S&T competencies and infrastructure.

Among the general questions that should be more broadly discussed are:

- *In which ways should policies for innovation be improved?* Although policy trends demonstrate that attention to innovation has become increasingly prominent in the agenda of government actions, the numbers (in terms of supported firms and budgets of certain programs) still appear insufficient.
- *Are policies for innovation mainly deficient in terms of design (focus and targets), or implementation? To what extent are problems related to a lack of demand for current policies?*
- *To what extent do governance (and cultural) aspects and deficiencies in institutional incentives (regulatory frameworks) prevent investments in public research (S&T institutions) from having a meaningful impact on national innovation?*
- *Is the current combination of policies to promote business innovation the most relevant to business needs? How can support for innovation policies best be expanded to meet the needs of a wider range of firms, particularly SMEs?*
- *How can the effectiveness of policies for innovation and public investments in support of innovation be improved?*

To conclude, we summarize six of the most important challenges and opportunities that should be addressed in seeking improved innovation outcomes in Brazil. They are: (1) framework and regulatory conditions, including market competition and knowledge accumulation incentives; (2) the relevance of international trade and investment policies to foster greater learning opportunities from global technologies; (3) the governance of public research and technology organizations, resulting improved people and physical asset capacities, and their linkage with business needs; (4) the broader challenge of improving the demand-related effectiveness of policies for innovation, with a particular focus on stimulating and being responsive to broader business demands for technology adoption; (5) how to best improve coordination across different types of policies for innovation; and finally and perhaps most importantly (6) how to link lessons from more systematic monitoring & evaluation and periodic public expenditure reviews with a process of continuous improvement of policy design and implementation. This is not an exhaustive list of concerns but rather illustrative of key issues to consider in any discussion on how to make public policies for innovation more effective in Brazil.

1) In terms of ***Framework and Regulatory Conditions***, this review examined several framework conditions that Brazil should improve to maximize innovation and opportunities for business development. Obstacles to productive investment and efficiency include barriers to entry, growth and exit of firms, lack of flexibility of markets, and other shortcomings in the broader business environment. Amongst these are: the legal framework for Intellectual Property Rights Protection (IPRs) and the effectiveness of the IPR system, including its enforcement and administrative capacity (e.g. reduction of backlog pending patent applications); and the regulatory framework for market competition, business creation and growth. Brazil appears to be performing

below many peer and OECD countries in terms of restrictions and associated burdens imposed by the regulatory framework. The country has also a high tax burden and an onerous tax system, excessive administrative burdens, and shallow credit markets. Some of the key questions to address include:

- *In improving the legal framework and functioning of IPR systems, which areas need to be addressed and in which ways to better incentivize innovation and technology diffusion? What are the international practices to promote IPRs?*

- *How much of the regulatory framework states at the federal level and how much is concentrated in regional administrations? What are the most relevant practices to make the regulatory framework for business creation and registration more business and innovation conducive?*

- *Which are the key reforms to be tackled in terms of competition regulation? How to advance competition in internal markets without the detriment of foreign direct investment?*

2) ***International trade and investment policies*** are critical to foster greater learning opportunities from global knowledge**.** With the *Brasil Maior Plan*, trade protection measures have increased as elements of industrial policy. They include tax breaks to benefit local producers, increased tariffs, and local content requirements. Although the level of tariffs varies widely across products and industries, 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 or to collaborate in the generation of new technologies with top global partners, hindering firms' pathway to innovation and productivity improvements. Given the evidence of positive effects related to tariff reductions on innovation and productivity, the desirability of reversing some of these policies should be explored. Overall, the state of framework conditions suffers from several weaknesses that could be hindering innovation potential of Brazilian firms. The following questions emerge from this discussion: [53]

- *How could Brazil better leverage innovation (and the impact of other policies for innovation) through trade and FDI? What does international evidence say about the interplay between international trade & investment and innovation policy?*

- *In fostering innovation, what are the benefits of accessing global technology markets relative to protecting domestic markets, and what other measures could reinforce acquisition of top global technologies?*

3) In terms of the ***regulatory framework and governance of public research & technology organizations and investments in upgrading Brazilian S&T talent,*** important reforms have been implemented but important gaps remain that hamper the development of industry-science linkages (and collaborative innovation) and the impact of public research and the build-up of S&T talent on business innovation. One of the political difficulties of the innovation system in Brazil is that it still has a strong academic bias, and with the exception of a handful of institutions, has persistent difficulties to operate in collaboration with firms, and there appear to be insufficient incentives for S&T talent to work in the private sector.

- *What are the obstacles (regulatory and non-regulatory) to industry-science collaboration in Brazil? What policy and governance reforms are needed to improve the impact of Brazilian S&T investments on the economy?*
- *Why has mission-oriented governance not been fully established economy-wide? How can the public research systems be tilted towards more mission-oriented governance (e.g. performance-funding and performance evaluation)?*
- *What are the possibilities and relevance for the Brazilian research system to adopt evaluation mechanisms as part of improved governance (performance evaluation and accountability of results) and to make public research more in line with international standards of excellence, and in line with international practices (e.g. the United Kingdom Research Excellence Framework)?*

These concerns highlight the need for a rigorous assessment of the regulatory framework and governance of the public research organizations, and the allocation of funding and incentives for S&T talent. The system also 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.

4) Regarding how to improve the ***demand-related effectiveness of policies for innovation,*** several questions emerge regarding the focus of policies ("policy mix") and their implementation, with a particular focus on stimulating and being responsive to broader business demands for technology adoption. There are at least three dimensions of the current policies for innovation that deserve discussion:

   i. The first dimension is the "*focus" or how to make policies for innovation in Brazil more balanced* between supply and demand incentives;

   ii. The second dimension is *how to better stimulate and respond to the different business demands for innovation* and have a better balance of policy measures and resources allocated to technology transfer and adoption (and incremental, catch-up innovation) versus R&D-based frontier innovation. This issue highlights the need for the development of an effective "*national technology extension system*", which to date is underdeveloped in Brazil, with the exception of agriculture extension;

   iii. The third dimension is *how to improve reach and impact of current policies*. In other words, how to make policy mechanisms (including existing ones) more accessible and reachable by SMEs, including new firms. Solving this question requires a diligent revision of how policies are being implemented and understand barriers that dissuade the demand and use of policies by SMEs.

This review highlighted the lower propensities of adoption of new technologies by Brazilian firms, and the gaps in terms of support for technology transfer, extension and adoption by firms across the economy. 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; though 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.

- *In line with international policy trends in developed economies, should Brazil reconsider and reinforce policies for innovation that target technology transfer and adoption, promoting incremental catch-up innovation across SMEs?*
- *What other actions should be considered to increase business demand for technology adoption and catch-up innovation, including possibly collective interventions and joint implementation with industry associations and regional economic organizations as in the case of several productivity programs of CORFO Chile (e.g. PROFOs)?*

From the review of policy programs and budgets, the largest public expenditures supporting firm innovation, credits and tax exemptions, are mostly used by large firms, and those firms that 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) new innovation by SMEs, including young firms; the participation of small firms in these programs, in terms of value of resources received, remains relatively unimportant.[54] It may be pertinent to address the following questions:

- *What are the limitations/obstacles in each of the programs impeding their more widespread use? Are current eligibility criteria and procedures inhibiting SMEs' demand for these policies? Are there other important institutional obstacles, such as compliance costs? Should co-financing or tax incentive rules be revisited and if so, in which ways?*
- *How should effective programs be expanded and reach the most relevant firms? What are the best practices to incentivize demand for targeted innovation policies?*
- *Should complementary incentives and assistance be considered, such as support in application preparation, voucher systems, subsidies to innovation management, or value chain approaches to link large firms with SMEs?*

5) ***The need to improve coordination across policies.*** In revisiting and assessing the effectiveness of support mechanisms for technology transfer and adoption, it may be equally if not more important to establish to what extent supply and demand side policies, and innovation and complementary productivity-upgrading polices may be desirable. This calls for better coordination across policies and agencies affecting innovation and productivity.

- *How can policies for innovation be made more impactful through better policy coordination? How can follow-up of firms across policy programs and over time be facilitated?*
- *How should the use of public resources be leveraged across both federal and regional levels? How well connected are regional economic policies (and policies for innovation) and their respective administrative agencies? Are there any successful policy coordination examples in Brazil, and what relevant international examples exist?*

6) More systematic ***Monitoring & Evaluation, supplemented by periodic Public Expenditure Reviews*** of policies for innovation. There is room to improve the effectiveness of policies for innovation. The Brazil government could improve policy learning and effectiveness through the more systematic adoption of M&E frameworks, which in addition to measuring the achievement of goals (effectiveness)

and the efficiency of programs, would permit adjustments to made over time in implementation based on continuous learning of which programs and instruments work well and which work less well. Apart from a few limited empirical assessments of R&D programs, there have been few efforts to systematically evaluate policy programs, especially regarding technology extension and other forms of technology transfer, and their impact on technology adoption and subsequent productivity upgrading by firms – including when these policies are most effective, including for which types of industries and firms. Adoption of more a systematic M&E framework across policies for innovation should be supplemented by periodic Public Expenditure Reviews of policies for innovation, to assess the quality of public spending on innovation, in terms of benefits relative to costs, and explore ways to enhance the quality of public spending on innovation.

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[1] See Nassif, Feijó and Araújo (2013).
[2] The Global Innovation Index 2014. Available on: https://www.globalinnovationindex.org/content.aspx?page=data-analysis
[3] 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.

[4] SCIMAGO (2014) online database based on SCOPUS (Elsevier) bibliographic data.
[5] See Dutz, Kannebley Jr., Scarpelli and Sharma (2012).
[6] See Dutz, Kannebley Jr., Scarpelli and Sharma (2012).
[7] 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.
[8] 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.
[9] 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.
[10] A number of papers show that ISO 9000 certification is correlated with direct measures of product quality (e.g. Carlsson and Carlsson 1996, Brown et al. 1998, and Withers and Ebrahimpour 2000). In an international study of manufacturing firms over 89 countries, 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.
[11] Terlaak and King (2006).
[12] 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).
[13] National Quality Infrastructure (NQI) refers to the set of country institutions that, supported by a national regulatory framework, provide the services (which can be public or private) to guarantee the quality and safety of products and services for local and international consumers. The PTB Quality Infrastructure Index is a composite indicator reflecting the level of development of the quality infrastructure, total calibration and measurement capabilities, total ISO-9000 issued; total accreditation bodies, technical committee participations in international standards and technical committees, and the number of memberships of international quality infrastructure system. The resulting composite indicator is weighted by population or by GDP. See Harmes-Liedtke and Oteiza di Matteo (2011), published by PTB (Physikalisch Technische Bundesalstalt).
[14] 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). The option of only relying on internal development (R&D) is less successful. For other countries, 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. Johnson (2002) had found similar evidence of a higher probability of innovation by firms that have previous experience with technology licensing.
[15] On “absorptive capacity”, see Rostow (1960); Cohen and Levinthal (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, 1997; Fabergerg *et al*, 1999).
[16] In the terms of Cohen and Levinthal (1989 and1990), having an internal knowledge capacity –as reflected in an internal R&D capacity-, “facilitates search-out of technologies, adoption and adaptation of external technology”
[17] 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.
[18] See Klenow and Hsieh (2007); Bergoeing *et al.*, (2006) and Caballero *et al* (2004).
[19] 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.

[20] 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.

[21] 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. Both studies used panel data. 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.

[22] See Gorodnichenko and Schnitzer (2013). For Chilean firms, Alvarez and Crespi (2012) found that financial constraints discourage firm innovation investment in both large and small firms and the impact of such constraints are twice as large in services industries compared to manufacturing. They explain that large firms encounter important financial constraints as well given that capital markets in developing countries are not deep and developed enough to finance innovation projects.

[23] The index measures the level of protection of the rights of borrowers and creditors as measured by laws and regulations.

[24] 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.

[25] Insead-PwC Study on Private Equity in Brazil

[26] 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.

[27] 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).

[28] 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.

[29] Park (2008) and Maskus (2000).

[30] The 2015 GIPC Index maps the IP environment of 30 economies, comprising nearly 80 percent of global gross domestic product (GDP). The GIPC Index consists of 30 indicators divided into 6 major categories. Each indicator is scored between 0 and 1. The maximum available score for the entire GIPC Index is 30.

[31] Malouche *et al.* (2013); UNCTAD, 2013; Cadot *et al*, 2012.

[32] See Cassiman and Veugelers (2002); Cassiman, Pérez-Castrillo, and Veugelers (2002) or Belderbos *et al* (2005).

[33] See Freel and Harrison (2006) and. Belderbos, Carree, and Lokshin (2004).

[34] OECD Science, Technology and Industry Outlook (2014).

[35] BNDES was created in 1952.

[36] 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).

[37] 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.

[38] 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.

[39] See Pages (2010) for further analysis 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 (Pages, 2010; Maffioli *et al*, 2010).

[40] See Maloney (2013).

[41] See Ibarragan *et al* (2010).

[42] Indicators available (only in Portuguese) in www.mcti.gov.br/indicadores.

[43] The program is executed jointly by CAPES and CNPq. Therefore, part of regular budget of these institutions is now attached to the program.

[44] Because it is a recent program, there is no evaluation of its results yet.

[45] Available only in Portuguese in http://download.finep.gov.br//processosContasAnuais/relatorio_gestao_fndct_2013.pdf , pg. 165.

[46] Annual Management Report of FNDCT, Available only in Portuguese in http://download.finep.gov.br//processosContasAnuais/relatorio_gestao_fndct_2013.pdf

[47] 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 2000's.

[48] Crocco and Santos (2011); in Ferraro and Stumpo (2010).

[49] 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.

[50] 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.

[51] Rogers (2014).

[53] As evidenced by a recent study, the productivity improvements that have occurred in manufacturing export enterprises in Brazil appear to have been driven by a reduction of tariffs on intermediate capital goods (World Bank 2014a).

[54] As discussed by several authors (e.g. Mancusi *et al*, 2014), a large part of the innovation investment gap (particularly in R&D) is explained by a lack of firms participating (a low propensity to invest) in these activities --which indicates high entry costs to engage in innovation.