Policies and Institutions Fostering Innovation and Agriculture Technologies in Brazil

Robson Braga de Andrade, National Industry Confederation (CNI), Social Services for the Industry (SESI), and the Brazilian National Service for Industrial Training (SENAI)

Guilherme Afif Domingos, Brazilian Micro and Small Business Support Service (Sebrae)

Compared with other developing countries, Brazil has a relatively well-developed innovation system and a favourable scientific infrastructure. It has several universities well placed in the world rankings, a growing role in world knowledge production, and a diversified economic structure.

However, from the point of view of the National Industry Confederation (CNI) and the Brazilian Micro and Small Business Support Service (Sebrae), the country still faces many challenges in fostering science and technology and in creating an environment more suitable for innovation. Perhaps the most successful example in Brazil of how policies and institutions can foster science and innovation oriented towards society's major goals is in the agricultural sector.

This chapter first aims to describe the main characteristics of the Brazilian innovation system and policies. Second, it provides evidence of the growing participation of a different set of agents in the country's innovation system. Finally, it depicts the country's agriculture research system and outlines improvements needed to address new technological challenges in agriculture and food production.

Brazil's innovation policies and institutions: The current scenario

Over the last 15 to 20 years, Brazil has greatly improved the policies that are intended to foster innovation. Indeed, the country has implemented a series of measures and policies to reinforce its innovation capacity. Among the new policies are research and development (R&D) tax incentives and subsidized credit for innovation, as well as some regulatory measures that ease the university-enterprise relationship. The Brazilian government also substantially increased public R&D expenditures, at least until the recent fiscal crisis in 2014.

Zuniga et al. have systematized the main public policies and instruments that currently exist in Brazil to support innovation (Table 1) as well as the estimated amount of money invested through these instruments in 2012.[1] Some of the funding sources for innovation indicated in the table, such as the mandatory R&D investments from companies in regulated sectors, are not strictly public. These investments are obligations assumed by companies in regulated sectors and are, therefore, private resources.[2]

According to De Negri, all this effort in designing new policies builds a relatively comprehensive picture of innovation policies when it comes to the diversity of instruments. She explains, 'Currently, the country can count on many of the instruments used in most of the developed world to foster innovation, such as: i) subsidized credit; ii) tax incentives; iii) subventions for companies (grants); iv) grants for research projects at universities and research centers, among others'.[3]

Some recent policies deserve special mention because of their role in the country's innovation system, specifically in the agriculture sector. The first relevant attempt to increase funding to foster innovation in the country was the creation of Sectoral Funds. These funds are meant to be defrayed by taxes or contributions levied on certain sectors and to support innovation projects in those sectors. The first of these funds, created in 1999, was the fund for the oil sector, financed by a share of oil and gas royalties.

One of the funds, for agribusiness, was created in 2001; it specifically aims to foster technologies in areas such as agronomy, veterinary medicine, biotechnology, economics, and agricultural sociology. This fund also intends to promote technological updates in the agricultural industry and to stimulate the expansion of investments in tropical agricultural biotechnology and in the diffusion of new technologies. Also created in 2001, the Biotechnology Fund aims to support technologies, research infrastructure, and qualification in the area. Another important sectoral fund for agriculture in Brazil is the Energy Fund, which is particularly concerned with improving energy efficiency and fostering renewable energy, such as biofuels.

The innovation law of 2004, in turn, established the rules of engagement for researchers from public institutions in research projects with

Table 1: Primary innovation and S&T policies and instruments in Brazil (main sources of funding for S&T), 2012

	Policies and Instruments	Value (Current *Reais*)
Tax breaks	Tax incentives for R&D stipulated by Law No. 11,196/2005 (the good law)	1,476.8
	Tax incentives from the Informatics Law (No. 8,248/1991 and No. 10,176/2001)	4,482.2
	Other tax incentives for innovation	464.0
	TOTAL (Tax Incentives)	**6,423.0**
Public credit for innovation (disbursements)[a]	FINEP	1,800.0
	BNDES	2,200.0
	TOTAL (public credit)	**4,000.0**
Public investments in S&T	States (excluding post-graduation)	7,033.7
	Federal Government (excluding post-graduation)	18,387.9
	TOTAL (excluding post-graduation)	**25,421.6**
	TOTAL (with post-graduation)	**40,045.0**
Mandatory investments in R&D for regulated companies	Electric Sector R&D Program (approximate values)	~ 300.0
	Oil Sector R&D Program	1,226.7
	TOTAL	**1,526.7**

Source: Extracted from Zuniga et al., 2016, Table 1, p. 63.

Data sources: ANEEL (Electricity Regulatory Agency database), available at http://www.aneel.gov.br/?idiomaAtual=1; ANP, 2013; BNDES, 2013; the Ministry of Science, Technology and Innovation (MCTI) database, available at www.mcti.gov.br/indicadores; and the Brazilian Innovation Agency (FINEP).

Note: a According to Zuniga et al., the value that expresses the subsidized credit for innovation is the total volume of the credit portfolio for innovation at BNDES and FINEP. In other words, this does not represent the implicit costs of such instruments for the Brazilian government. BNDES = National Bank for Social and Economic Development; FINEP = Brazilian Innovation Agency; S&T = science and technology.

companies, as well as for the commercialization of intellectual property derived from these partnerships. This was a significant improvement in the regulations concerned with the interaction between universities and companies. This law also launched the possibility of public funds being given to companies in the form of a grant for carrying out R&D. Until the promulgation of this law, there had been no such possibility in the Brazilian legal framework.

Finally, the 'Good Law' (Lei do Bem) generated several tax incentives for Brazilian companies in 2005. When it comes to innovation, one of the most important of these is the tax incentives for private investments in R&D. Before this law there were two programmes that provided tax breaks to private companies that invested in R&D in both industry and agriculture. Those programmes demanded that, before receiving the incentive, companies should have their research projects approved by the Ministry of Science and Technology. The bureaucracy involved in this kind of requirement was responsible for this earlier incentive never having been broadly used by Brazilian companies—either in industry or in agriculture. The Good Law, therefore, expanded the comprehensiveness of the tax incentives and facilitated its use for private companies conducting R&D in the country.

From the regulatory point of view, several improvements have been made in Brazilian legislation in the last decades. These begin with the Industrial Property law, approved in 1996, and the cultivars protection law, in 1997. Besides these, a new law on biodiversity made research on Brazilian biodiversity easier. This law entered into force in 2015 and, from this date, research using Brazilian genetic resources, as well as the development of products based on the country's biodiversity, do not require prior authorization.

The emerging role of CNI and Sebrae

New institutional actors have recently emerged as important players in the Brazilian debate on innovation and technology. CNI business leaders created the Entrepreneurial Mobilization for Innovation (MEI) in 2008. The MEI aims to make innovation a centre of corporate strategies and increase the effectiveness of innovation policies in the country. This initiative recognizes that innovation is essential for competitiveness and, therefore, for the country's growth and development. Currently, the MEI has around 200 business leaders as members and counts on support from government working in partnership to strengthen innovation in Brazil.[4]

Besides mobilizing Brazilian entrepreneurs, the CNI, by means of the Brazilian National Service for Industrial Training (SENAI), has also created several new technological institutes in the country. The SENAI institutes of innovation were inspired by the German model of the Fraunhofer Institutes, and they aim to increase the productivity and competitiveness of Brazilian industry by developing innovative solutions for companies of all sizes.

Until now, 21 different institutes have been established to conduct applied R&D, providing technological and laboratory support for prototyping and pilot plants, as well as consultancy work to facilitate technology transfer to Brazilian companies. These institutes are spread over 12 different states of the country. For instance, the Institute of Innovation in Biotechnology, in São Paulo, develops innovative solutions for bioengineering focused on areas such as food processing, chemistry, and energy, among others. The Institute for Biomass Innovation, in Três Lagoas in the state of Minas Gerais, offers solutions in biomass processing for sugar and ethanol producers, pulp and paper, biofuels and biodiesel, and the chemical sectors.

Brazil also has an important network of public and private providers of technology extension services for small and medium-sized enterprises. These services include training in technology and managerial skills, in the diffusion of information, and in metrological services.

The most important organization providing these services and supporting micro and small enterprise development in Brazil is the Brazilian Micro and Small Business Support Service (Sebrae), created in 1972 by the Brazilian government. Sebrae became independent, as a private nonprofit organization, in 1990. It develops its activities in collaboration with the public and private sectors through its National Deliberative Council, which includes government institutions, business organizations, and research institutions.[5] Sebrae offers several solutions in different areas of business organization, among them innovation. Specific programmes to foster innovation have been created.

One of these is SEBRAETEC, a programme that allows small businesses access to technological and innovation support in order to improve processes, products, and services and to introduce innovation in enterprises and markets in the following areas: quality, productivity, intellectual property, sustainability, digital services, and design. Sebrae pays 70% of the company´s innovation costs, and the company is responsible for 30%. Some specific examples of services covered by SEBRAETEC in agriculture and food production are:

- genetic selection in the search for yield increase, because this diagnoses genetic problems that affect fertility, diseases, longevity, and quality in milk and animal farming;
- good agricultural practices and HACCP (Hazard Analysis & Critical Control Points) needed to meet the required standards for wholesale markets and export markets for fruits, vegetables, coffee, honey, distilled beverages (cachaça), and agroindustry products;
- laboratory analysis for quality diagnosis and monitoring, such as water quality parameters for fish and shrimp farming, microbial standards for milk and for sugarcane juice (for cachaça production), and soil tests;
- technical assistance for several types of crops; and
- assistance in meeting the country´s Technical Norms and Standards.[6]

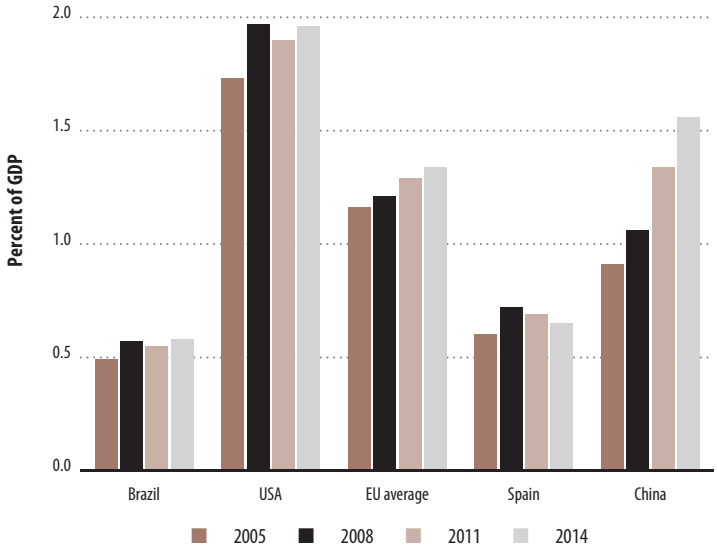
Outcomes and challenges

In terms of innovation policies and the engagement of society in knowledge production, it is possible to conclude that Brazil has achieved important advances in the last decade. One indication of this broader coverage of the policies appears in the latest Brazilian innovation survey.[7] The survey indicates that the share of innovative companies reporting having received public support to innovate has reached about 40%, compared with around 20% in the early 2000s.

The framework of Brazilian innovation policies is broader than it used to be. When it comes to their effectiveness, the results are not so clear. Different researchers in the country have carried out some studies to evaluate the effectiveness of several of these policies.[8] These evaluations, however, are not regular and systematic and are not frequently used by the government to redesign the policies. To some extent Brazilian innovation policies have been known to inspire good examples around the world, although the policy design should eventually be improved. Some studies also suggest that some of the policies adopted are not crowding out but are instead stimulating private investment in R&D.[9] Tax incentives from The Good Law, for instance, have been evaluated by several researchers.[10] The results from these studies, as well as testimonies from several Brazilian industrial leaders, suggest that the effects of this incentive are relevant for Brazilian industry. However, several other policies need much better evaluation.

Indeed, improving the evaluation of innovation policies in Brazil

Figure 1: Business R&D investments (BERD) as a share of GDP, Brazil and selected countries (2005, 2008, 2011, and 2014)



Source: IBGE, 2016; OECD, Innovation in Science, Tewchnology and Industry database, available at http://www.oecd.org/sti/inno/, accessed February 2017.

Note: The European Union member states are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

is crucial, especially in terms of data transparency and accountability. The agencies responsible for supporting innovation should be more committed to evaluation and to the creation and disclosure of indicators and data on the policies. The ministries and public agencies responsible should provide incentive for the creation of some key performance indicators to evaluate the policies under their responsibility. Reinforcing transparency and accountability is, in fact, the only way to improve the assessment of the results of innovation policies.

A more in-depth evaluation could help with an understanding, for example, why—despite the creation and consolidation of several public policies for innovation—overall Brazilian performance on several innovation indicators is still lacking in efficacy. The country's position in the Global Innovation Index (GII) is not improving over the years. On the contrary, in 2011, Brazil held 47th place in the GII rankings; in 2016, the country ranked 69th.[11]

Figure 1 shows business R&D investments (BERD) as a share of GDP. The stability of the Brazil's performance over the years, especially after 2008, is evident. Compared to the performance of most other countries, the country is clearly lagging behind.

Why is this happening? Despite all the efforts that have been made in terms of public policies, why are the aggregate results of the country still weaker than expected? According to De Negri, part of this can be explained by the decrease of industry's share in GDP, since this sector is responsible for a great share of total R&D investment in the country.[12] There are other relevant constraints, however, that prevent the Brazilian economy from becoming more innovative; these constraints equally affect industry and agriculture.

The first obstacle is a very bureaucratic and rigid business environment. One of the indicators of such an environment is the time necessary for an entrepreneur to start a new business: in Brazil, this is more than 100 days. To answer to the demands of the market and to create new products and processes to meet these demands, agility and flexibility are crucial. It is not by chance that the institutional dimension is where Brazil has the worst GII scores. Even worse, the indicators on this dimension show no improvement over the last few years. That is a serious deficiency for the country, and it is time to address it.

The second relevant factor hindering the country's innovation performance is competition and integration with international markets. To foster competition, it is important for Brazil to build an economy that is more integrated in global value chains and international markets. The country needs to foster internationalization—not only in terms of goods and services, but also in terms of knowledge, ideas, and human capital.

Finally, there is a need for readily effective and focused public policies. In spite of the fact that some policies are relatively well evaluated, the country still has to make them more mission-oriented than before. One of the gaps apparent in the Brazilian innovation system is the lack of interaction between universities and research centres, on one hand, and companies on the other. It is necessary to build instruments able to integrate scientific production, knowledge, and technologies with the greater needs of Brazilian society.

In this regard, the innovation system in Brazil's agriculture sector is a great example to follow.

Fostering technologies for agriculture and food production: The challenges ahead

In addition to improving the business environment and building a more internationalized economy, one of the major challenges for Brazilian innovation policies is their ability to promote, in a more intensive way, a kind of R&D geared to the greater needs of Brazilian society—research that is sometimes called 'mission-oriented R&D'. The agriculture sector in Brazil is one of the best examples of how to support mission-oriented R&D.

Throughout its history, Brazil has established a broad and competitive R&D system focused on the agriculture sector. The National Agricultural Research System (SNPA), established in 1992 by ordinance of the Ministry of Agriculture, Livestock and Food Supply, has been able to develop technological innovations that were critical for agribusiness expansion in the country. From more resistant and productive seed varieties to new cultivation techniques, the technologies developed by the SNPA made it possible to grow soybeans in the Brazilian Cerrado.

The system includes institutions such as the Brazilian Agriculture Research Corporation (Embrapa), the State Agricultural Research Organizations (OEPAS), universities, and federal and state research institutions as well as other organizations related to agriculture research. The Agronomic Institute of Campinas (IAC), for instance, founded in 1887, is one of the oldest research institutions in the country and one of those responsible for developing several agriculture technologies. The entire system comprises a very diverse set of institutions—each with several different characteristics and roles—that work together to sustain a virtuous process of innovation in agriculture sector.

Embrapa, a public research institution founded in 1973 under the stewardship of the Ministry of Agriculture, Livestock, and Food Supply, plays a leadership role in this system. Currently, the institution counts on a budget of around 3 billion Brazilian reais (R$) and more than 9,000 employees. It operates through 46 decentralized research units spread out in almost every state in the country. The research portfolio of the agency includes projects such as (1) diagnosing the physical, chemical, and microbiological quality of soils; (2) identifying and mapping weeds resistant to herbicides; (3) using geotechnologies (such as those that map rainfall); and (4) conserving plant growth–promoting microorganisms by working with biological nitrogen fixation and other mechanisms.

Embrapa is also known for its strong use of intellectual property protection and has served as a model for other centres on how to manage technology and technology transfer to other companies and institutions. Embrapa´s Technology Transfer Office staff is recognized as a group of well-trained and competent professionals and Embrapa is among the top patent applicants in the country.

One of the main advantages of this system is its proximity and close relation to farmers, which allows it to provide them with the necessary solutions to their problems. It has proved to be very successful in providing Brazilian farmers with new technologies in areas such as genetic engineering, soil improvement and correction, plant and animal breeding, livestock technologies, and so on. However, some researchers are pointing to the risk that the country will lose technological leadership in several areas in which it has already had a strong influence, falling behind the technological frontier in agriculture. The main challenges in this regard are the human capital and scientific competences in agriculture research. To overcome this risk, Bonacelli et al. suggest an urgent reorientation of policies for agriculture that takes into account new technologies and new scientific competencies.[13]

This reorientation is even more important in face of new trends and challenges in agriculture technologies. Improvements in agricultural productivity and sustainability nowadays depend much more heavily on industrial technologies provided by the agricultural inputs industry than ever before. The *Business Insider Review,*[14] for instance, as well as other technological publications,[15] have listed some of the main emerging agriculture technologies over the next several years.

Sensors are making farms smarter and more connected, which enables real-time traceability as well as the diagnosis of crop and soil conditions, and the monitoring of livestock and farm machinery in real time. Sensors can be useful in several types of situations. Collars with chips and biometrics can identify and monitor vital information about livestock in real time. Crop sensors could prescribe the correct amount of fertilizers to apply to a specific site at a specific point in time, and this information could be sent directly to the application equipment.

Information technology can connect all the machinery and sensors in a farm to provide real-time information and to adopt the measures necessary to solve several kinds of problem. The adequate treatment of the vast amounts of data from crop yields,

soil-mapping, fertilizer applications, weather data, machinery, animal health, and so on can make farms much more efficient than before.

Precision agriculture will enable farming management based on observing all these kinds of data and providing adequate answers. Besides that, 'further understanding of crop variability, geo-located weather data and precise sensors should allow improved automated decision-making and complementary planting techniques'.[16]

The food processing industry could also benefit greatly from genetic engineering to create 'new strains of food animals and plants in order to better address biological and physiological needs'.[17] Automation continues to be an important tool for improving agriculture productivity. Nowadays automation also implies using drones, robots, machine learning, and Internet of Things (IoT) technologies.

There are several examples of these technologies that are already developed or in development in Brazil. Embrapa, for instance, has developed the 'electronic tongue' (a conductive and lipid-based sensor for the taste evaluation of beverages) and an irrigation sensor that informs the producer about the need for water in the soil. The combination of sensors and information technologies is the focus of a product developed by a start-up company that allows consumers to track the origin of meat. Another Brazilian company is developing solutions for topography, pest detection, and cattle counting using drones.

The fact that most new agriculture technologies are coming from the input industry—including machinery, agriculture chemical, animal genetics, seeds—demonstrates the enormous challenges faced by the agricultural research system, both in Brazil and in general. Although it has the biggest tropical agriculture industry in the world, until now Brazil has not been able to take advantage of this large-scale production to create a competitive and internationalized input industry. In fact, despite having produced several important technologies for the agriculture sector, there are few internationally competitive Brazilian companies in either the food production chain or in the agricultural input market. Indeed, in the list of the major food-processing companies in the world, there is just one Brazilian company, which is in the meat industry. The Brazilian international presence in the agriculture input industry—such as crop seed/biotech, agricultural chemicals, animal health and breeding, and farm machinery industries—is also not as relevant as it could be given the size of its agriculture sector.

Moreover, increasing global market concentration in the agriculture input industry—as noted by the United States Department of Agriculture (USDA)—implies that fewer firms are now responsible for many of the innovations that result in growth in agriculture productivity.[18]

Conclusions

For Brazil to play a leading role in the most important technological trends in agriculture today, it is vital that the country place the technologies of industry and services at the service of agriculture. Thus, from the perspective of CNI and Sebrae, some challenges faced by Brazilian agriculture need much more attention from public policies and the agriculture research system. These challenges are related, among others, to determining the best way to:

- intensify the adoption of precision agriculture and zootechnics, genetics, geo-technology, big data, robots, drones, and artificial intelligence;
- increase the use of sustainable production processes;
- incorporate low-cost technologies, product innovations, and business model innovations into family agriculture; and
- intensify the use of software and mobile applications to support business management in the areas of logistics, farm finance, traceability, weather information, e-commerce, and cooperative organizations´ management.

The challenge presented by these trends is to make it possible for smallholders as well as large farms to access the new technologies so that they too can benefit from the promise of productivity and quality offered by these innovations. Several of these technological trends and challenges also constitute opportunities for small business, especially in the service sector. The implications for the Brazilian innovation system in agriculture are huge. They demand a new vision with policies oriented towards fostering innovation in agriculture to prevent the country from being relegated to only using new technologies instead of also generating them.

It is necessary, for instance, that the government continue to sponsor research to develop and deliver new technologies to Brazilian farms. To address the challenges above, it is also necessary to integrate agriculture needs with industry and services inputs. To provide just one example, the European Union, under the umbrella of the Horizon 2020, is sponsoring projects that look at the feasibility of bringing cost-effective precision farming tools from the laboratory to the farm.[19]

Besides designing more focused innovation policies, it is vital to solve some of other challenges mentioned earlier. Reducing bureaucracy and improving the business environment could be an important boost to the generation of new ideas and the creation of new businesses that could take advantage of the huge size of the Brazilian agriculture market. It is also imperative to look abroad and be connected to the main trends in agriculture research, which implies modernizing and internationalizing Brazilian research institutions and companies.

Notes

1 This table was extracted from Zuniga et al., 2016, p. 63; it is the only known attempt to systematize in a single table all the public policies for innovation in Brazil. Unfortunately, they have not updated the data.

2 Zuniga et al., 2016.

3 De Negri, 2015, p. 2.

4 CNI, 2016.

5 Zuniga et al., 2016.

6 Brazil's technical norms for food and beverage production are regulated by ANVISA (Agência Nacional de Vigilância Sanitária).

7 This survey was conducted by the Instituto Brasileiro de Geografia e Estatística. See IBGE 2016.

8 Zuniga et al. (2016) mention a few of these studies. The main institutions producing evaluation studies in Brazil are the Institute for Applied Economic Research (IPEA), the Center for Strategic Studies and Management (CGEE), and some universities such as Unicamp.

9 Zuniga et al., 2016.

10 Zuniga et al., 2016.

11 CNI, 2016.

12 De Negri, 2016.

13 Bonacelli et al., 2016.

14 Zappa, 2014.

15 See also Leclerc, 2016.

16 Zappa, 2014.

17 Zappa, 2014.

18 Fuglie et al., 2012.

19 For information about the European Union's Horizon 2020 programme, see https://ec.europa.eu/programmes/horizon2020/.

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