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The Brazilian Innovation System:
A Mission-Oriented Policy Proposal

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The Brazilian Innovation System: A Mission-Oriented Policy Proposal

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Executive Summary

Introduction

Countries around the world are seeking to achieve economic growth that is smart (innovation-led), inclusive, and sustainable. Such a goal requires a rethinking of the role of government and public policy in the economy. In particular, it requires a new justification of government intervention that goes beyond the usual one of simply fixing market failures.

In this context, innovation policy is about identifying and articulating new *missions* that can galvanize production, distribution, and consumption patterns across sectors. Mission-oriented policies can be defined as systemic public policies that draw on frontier knowledge to attain specific goals or 'big science deployed to meet big problems'.Tackling innovation missions – whether traveling to the moon or battling climate change – requires investments by both private and public actors. The role of the public sector will be particularly important in the early, capital-intensive high-risk areas that the private sector tends to shy away from. But more generally, there is a catalytic role for Government in *creating and shaping markets* through dynamic public private partnerships.

For Brazil, this new *mission-oriented* approach means developing, implementing and monitoring a strategic innovation policy program that draws on the strengths of its innovation system to overcome the country's weaknesses and address its challenges, seizing the opportunities offered by such a vast and richly endowed country. It requires putting innovation at the heart of economic growth policy—bringing more coherence between the Finance Ministry and the Ministry for Science and Technology (MCTI).

Currently, it also means challenging austere economic policies so that fiscal restraints do not damage long-run growth. Public investments in R&D and innovation are *productivity-enhancing*, creating well-paid jobs and with higher multiplier effects than other governmental expenditures. Such investments can therefore help rebalance the public budget in the longer term by increasing future revenues. Such dynamic effects are often neglected in fiscal adjustment programs.

The main goal of this study is to suggest policy initiatives that will enable the Brazilian national innovation system (NIS) to become more mission-oriented through purposeful policies promoted by the state in direct partnership with the

private sector. This report proposes *a process by which Brazil can identify its missions from the bottom up.*

In this executive summary, we highlight key theoretical concepts used to analyze the Brazilian national system of innovation (NSI). Our analysis drew on our accumulated knowledge on international policy experiences and focused on the evaluation of policy documents and the review of specialized academic literature, which was complemented with interviews we conducted with 35 representatives from the public sector, private sector institutions, and quasi-governmental institutions. Based on our analysis of the Brazilian NSI and of the interview findings, we develop policy recommendations that we also summarize here.

A mission-oriented policy framework: key concepts

Our approach to formulating a new mission-oriented innovation policy is based on seven key principles, conforming our policy framework:

1. Innovation policy must build on the key characteristics of how innovation comes about: it is uncertain; cumulative; and collective. Uncertainty means that agents concerned with innovation cannot calculate in advance the odds of success or failure – that is, results are unknown – and therefore in order to succeed will have also to accept occasional failures and detours from planned routes. Cumulative means that agents need to be patient and act strategically to accumulate competences and capabilities (learn) with a view to the long run. Collective means that all agents need to work together and thus bear certain degrees of risk; they are therefore entitled to also share the rewards.

2. Policies based on a mission-oriented perspective are systemic, employing but going beyond science-push instruments and horizontal instruments. Mission-oriented policies employ the array of financial and non-financial instruments to promote the accomplishment of a mission across many different sectors, setting concrete directions for the economy, and deploying the necessary network of relevant public and private agents.

3. A *broad perspective* on the national system of innovation identifies four subsystems: (i) public policy and public funding; (ii) research and education; (ii) production and innovation; and (iv) private finance and private funding. While all subsystems are theoretically of strategic importance, the subsystem of public policy and funding has traditionally led the process of socio-economic development and technical change.

4. In order to stimulate the innovation process by shaping and creating technologies, sectors, and markets, new relationships must be developed and more trust must be created. The state must galvanize the interests of relevant actors and organize itself so that it has the 'intelligence' to think big and formulate bold policies that also create a sense of ownership amongst diverse public, private, and academic stakeholders. It is also crucial to be able to implement the policies by coordinating the efforts of this network of stakeholders through the state's convening power, brokering of trust relationships, and the use of targeted policy instruments.

5. Systemic mission-oriented policies must be based on a sound and clear diagnosis and prognosis (foresight). This requires not only the identification of missing links, failures and bottlenecks – the weaknesses or challenges of a national system of innovation – but also identification of the system's strengths. Foresight is necessary in order to scrutinize future opportunities and also identify how strengths may be used to overcome weaknesses. This diagnosis should be used in devising concrete strategies, new institutions and new linkages in the innovation system. It may also be necessary to 'tilt' the playing field in the direction of the mission being pursued rather than 'leveling' it through such means as technologically neutral policies.

6. To fulfill a mission, a country requires an entrepreneurial state. This concept encapsulates the risk-taking role the state has played in the few countries that have managed to achieve innovation-led growth. It is through mission-oriented policy initiatives and investments across the entire innovation process – from basic research to early-stage seed financing of companies – that the state is able to have a greater impact on economic development.

7. The state must be able to learn from experience in mission-oriented innovation policy. In a market failure framework, *ex-ante* analysis aims to estimate benefits and costs (including those associated with government failures) and *ex-post* analysis seeks to verify whether the estimates were correct and the market failure successfully addressed. A mission-oriented framework requires continuous and dynamic monitoring and evaluation throughout the innovation policy process.

Building a mission-oriented policy agenda for Brazil

Brazil's current political and economic situation poses a huge challenge in a country whose socio-economic development is still incomplete. Corruption scandals seem to have frozen the agenda in Congress, preventing the passage

of bills that are important for innovation and economic development, such as reform of the tax code or changes to procurement legislation to allow the strategic use of public procurement for innovation.

In addition, the federal government has decided to implement an austere macroeconomic policy program, despite evidence that such pro-cyclical policies have not succeeded in other countries (IMF, 2012). Therefore, policy recommendations will need to consider the limitations imposed by the political context, including a limited public budget for public investments.

Notwithstanding these obstacles, it *is* possible for Brazil to establish a positive long-term agenda for development and sow the seeds for transforming its national innovation system to be more mission-oriented. To do so, policies should aim to address the weaknesses of Brazil's NSI and build on its strengths. The interviews we conducted, along with our own analysis of the Brazilian NSI, identified key strengths and weakness of the system.

The Brazilian innovation system has the following **STRENGTHS**:

- The presence of all the elements of a developed system of innovation (that is, key institutions exists in all subsystems: subsystem of education and research, subsystem of production and innovation, subsystem of public and private funding, subsystem of policies and regulation);
- A subsystem of scientific research that has substantially improved in the last few decades and is producing frontier knowledge in some key areas, with 'islands of productive excellence' in sectors such as oil and gas, aviation, agriculture, health, and, to a lesser extent, banking automation;
- Strategic natural assets (e.g. mineral and water resources, plus biodiversity of Brazil's six land biomes and its maritime biome) that in the long run will be increasingly demanded as the process of economic inclusion goes forward in emerging economies;
- A multifaceted state apparatus of agencies devoted to the promotion and execution of science, technology, and innovation policies, including a full toolbox of supply- and demand-side instruments;
- A strong domestic market for mass consumption, which has grown as a result of socio-inclusion policies;
- Public financial resources for R&D and innovation that (in principle) are not affected by budgetary fluctuations or cuts, such as the sectoral funds and the funding from BNDES that does not come from the Treasury;
- Positive examples of systemic 'mission-oriented' policy initiatives, explicitly or implicitly focused on innovation, that lead to positive interactions between the state, the business sector, and academia.

These include the *Inova* program, health policies, and, to a lesser extent, initiatives spearheaded by Embrapa and Petrobras.
- Existing complementary policies that may work as enablers of mission-oriented policy programs in national defense and security, and in climate, environment, and energy.

As regards **WEAKNESSES**, the Brazilian innovation system:

- lacks a consistent long-term strategic agenda (a vision) that gives coherence to public policies carried out by the different public institutions and gives direction to scientific research and to private agents in their innovation efforts;
- displays fragmentation (even antagonism) between the subsystem of education and research and the subsystem of production and innovation, due to the self-orientation of scientific research, and a lack of demand from business for the knowledge produced in academia;
- displays a low propensity to innovate in the subsystem of production and innovation - business expenditure on R&D (BERD) is very low, reaching just 0.50 percent of GDP in 2013;
- suffers from inefficiencies in the subsystem of policy and regulation, specifically: overlapping responsibilities, competition for and non-strategic use of resources, discontinuity of investments and programs, excessive bureaucracy, and control (auditing) of innovation policies and programs, including procurement, in the same way as for other programs;
- requires important institutional reforms in the taxation and regulation of business; and
- is constantly negatively affected by the implicit policies represented by the macroeconomic agenda.

Many of these strengths and weaknesses have long been the focus of public policies, either to build on the strengths or to address the weaknesses. Our analysis of Brazil's *explicit* innovation policies (that is, those led by MCTI and encapsulated in science, technology and innovation policy plans) suggests that previous policies have failed due to being based on a restrictive market failure perspective. This led to *ad hoc* and non-systemic projects (many of which had a science-push bias), with the notable exception of the *Inova program* and innovation policies for the health sector. So far, however, science–push policies (like the establishment of technological parks) have had little positive impact on the structure of production or the propensity of firms to innovate.

The study also analyzes the *implicit* innovation policies that are represented by Brazil's macroeconomic regime, and *complementary/enabling* policies, namely: health, defense, socio-economic inclusion, education, climate, environment, and energy:

- Brazil's macroeconomic policy framework of inflation targeting, exchange rate fluctuation, primary surpluses, and expenditure cuts (austerity policies) tends to impair the effectiveness of explicit industrial and innovation policies. This does not mean that innovation policy attempts will necessarily be in vain, but it does mean that public resources for R&D and innovation and innovation policy instruments need to be used strategically.
- Brazil's health strategy is a well-developed state-led policy that has been able to mobilize a range of public and private actors to develop science- and technology-based innovations. Unlike other sectors, the health sector has been able to foster partnerships between government, business and academia. It can be seen as a systemic mission-oriented strategy, with the use of regulation and public procurement complementing public investments and public-private partnerships in health innovation.
- While the National Defense Strategy represents an enabling framework for the establishment of mission-oriented programs, the effectiveness of these programs requires public policy measures to be fine-tuned to the industrial and technological challenges of the Brazilian defense sector and its spillovers to other sectors.
- There is great potential in the association of socio-economic inclusion and education policies with the policies to promote entrepreneurship and microcredit within the scope of local productive arrangement (APL) and regional development policies. The inclusion of social classes with lower income and the focus on the domestic market has yielded positive outcomes, resulting in the inclusion of vast portions of the Brazilian population and greatly increasing the potential market for consumer goods – and innovation.
- While they do not yet have a systemic design, Brazil's National Policy on Climate Change (NPCC) and associated environmental and energy policies are an enabling legislation for the establishment of mission-oriented innovation programs to address environmental challenges.

One strength and one weakness identified in our report point to a possible strategy that can help address the key barriers for the Brazilian system of innovation to thrive. These are the existence of positive cases of what can be regarded as mission-oriented policy programs and the need for a consistent

long-term strategic agenda that gives coherence to public policies and a direction to research and innovation. Well-defined missions provide a sense of *direction* to guide the evolution of all parts of the innovation system in responding to societal demands.

Looking at the two examples of relatively successful mission-oriented policies in Brazil – the policies for the health sector and the *Inova* program – we can ascribe the success of these programs to the presence of six crucial characteristics:

i. **Scientific-technological capacity:** an appropriate scientific and technological knowledge base in the subsystem of education and research;
ii. **Demand capacity:** latent or effective (public or private) market demand, in terms of both purchasing power and need;
iii. **Productive capacity:** an appropriate business base (for example, existing firms or entrepreneurs willing to take risks to establish an innovative firm) in the subsystem of production and innovation;
iv. **State capacity:** appropriate knowledge inside the public organizations formulating and executing the policies about the problem and solution being targeted and/or knowledge about who-knows-what-and-how;
v. **Policy capacity**: appropriate supply-side and demand-side policy instruments (strategically deployed), supported by complementary policies;
vi. **Foresight capacity:** a fine-tuned diagnosis of the problem and solution, including an analysis of the current situation and future prospects for targeted technologies and sectors, formulated in terms of a well-defined mission and vision.

Successful mission-oriented policy experiments in Brazil (e.g. health policies and the PAISS program) had all six factors in place whereas in less successful areas (e.g. *Inova Petro*, *Inova Defesa*, *Inova Energia* and *Inova Sustentabilidade*), at least one of the six capabilities was lacking. Three mechanisms (more or less present in the successful *Inova* sub-programs and in the Brazilian health policies) facilitate the creation of capacities during the mission-oriented policy process itself. These are (1) mechanisms promoting cooperation, amongst, for example, research labs, research and business, business consortia; (2) mechanisms for competition, for example, the open 'call for project proposals' of the *Inova* program; and (3) mechanisms for evaluation and accountability, which prevent deviations from program and, more crucially, allow for learning and knowledge accumulation.

Recommendations

Based on our analysis, we make the following recommendations for an alternative agenda to the policies currently in place in Brazil:

1. Macroeconomic policies and complementary policies could be made more supportive of explicit innovation policy programs.

2. There are some inefficiencies in the subsystem of policy and regulation that require legislative action – such as reforming the complex Brazilian tax system or removing the barriers to implementing public procurement for innovation.

3. Mechanisms for competition, cooperation, and accountability should be established and reinforced in mission-oriented policy programs, in order to help balance the relative roles of state, business sector, and academia.

4. In the light of the findings from this report, a detailed (re)evaluation of Brazilian 'mission-oriented' policy experiments should be carried out, as these experiments represent rich opportunities for institutional learning by the public agencies concerned.

5. Successful features of learning organizations should be emulated in other public agencies, taking account of context, capabilities, competences and constraints, by creating mission-oriented networks and partnerships.

6. The missions chosen should reflect best practice, as set out in this report. They should be feasible, draw on existing public and private resources, be amenable to existing policy instruments, and command broad and continuous political support. Missions should create a long-term state agenda for innovation policies, address a societal demand or need, and draw on the high potential of the Brazilian science and technology system to develop innovations.

7. As well as continuing, improving and expanding successful ongoing mission-oriented initiatives – health policies and the *Inova* program – we recommend that detailed diagnoses and prognoses – with the identification of existing capacities and of those that will need to be created – be prepared for other potential missions (*Urban, suburban and interurban infrastructure*; *Public service and public infrastructure*; *Agribusiness and familiar agriculture*; *Energy and the environment*; and *National security*).

8. Missions should, where feasible, be designed in a way that contributes to tackling inequality. Some will do this directly, others indirectly. In some cases, complementary investment in infrastructure and skills will be required if innovation policies are to be effective in addressing inequality.

A mission-oriented policy agenda based on these recommendations would increase the effectiveness of innovation policy in Brazil. It would also have the potential to help rebalance public finances, not by cutting expenditures – as in the prevailing austerity agenda – but by increasing strategic investments and future revenues. By engaging in a mission-oriented policy effort, Brazil should again be able to define the direction and ambition of its own development trajectory

"The important thing for Government is not to do things which individuals are doing already, and to do them a little better or a little worse; but to do those things which at present are not done at all."

John M. Keynes (1926), *The End of Laissez Faire*, p. 46

1. Introduction

1.1. Back to the future: the mission-oriented innovation policy agenda

Countries around the world are seeking to achieve economic growth that is smart (innovation-led), inclusive, and sustainable. Such a goal requires a rethinking of the role of government and public policy in the economy. In particular, it requires a new justification of government intervention that goes beyond the usual one of simply fixing market failures; markets must be actively shaped and created through dynamic public and private interactions (Mazzucato, 2015). In this context, innovation policy is not just about nurturing individual technologies and sectors, but about identifying and articulating new *missions* that can galvanize production, distribution, and consumption patterns across sectors. Mission-oriented policies can be defined as systemic public policies that draw on frontier knowledge to attain specific goals or "big science deployed to meet big problems" (Ergas, 1987, p. 53).

Innovation missions – whether traveling to the moon or battling climate change – require investments by both private and public actors. The role of the public sector will be particularly important in the early, capital-intensive high-risk areas that the private sector tends to shy away from. A state is considered 'entrepreneurial' when it invests in areas of extreme uncertainty, targeting both the rate and the *direction* of change (Mazzucato, 2013). A decentralized and networked developmental state (Block and Keller, 2011) works both top-down and bottom-up across numerous different agencies, organizations, and institutions. The success of Silicon Valley is due to the ability of such organizations to embrace the risk and uncertainty that exists throughout the innovation chain, from basic research to downstream commercialization (Mazzucato, 2013). Such organizations must be willing to experiment, and learn from trial and error; this is what Hirschman (1967) called "policy as process".

Most importantly, an entrepreneurial state must be able to think big and to venture into new areas, beyond the limits of current market structures. Today,

however, it is increasingly difficult for states to think big. Since the 1970s, the idea of government as a regulator and administrator has become prevalent, alongside attempts to downsize the state (Judt, 2011). The role of governments is often seen as passive, limited to simply “leveling the playing field”, “getting the institutions right”, and “solving market failures. Since the Global Financial Crisis, the emphasis on cutting public debt (even though it was escalating *private* debt that triggered the crisis) has inevitably affected the budgets of the very state agencies that have been responsible for the investments and policies necessary to catalyze technological revolutions.

Thinking big, however, does not mean throwing public money at different activities. It requires a new policy framework that can underpin the role of the public sector – in partnership with business and academia – in directing socio-economic and technological change. It requires mission-oriented innovation to be put at the center of economic policy and a framework that recognizes the catalytic role of government in creating and shaping markets, not just fixing them. It requires new indicators by which to evaluate public investments, capturing the transformational and catalytic impact. It requires different insights into the organization of government and the distribution of risks and rewards that emerge from the collective effort in pursuit of smart innovation-led growth.

For Brazil, this means developing a strategic innovation policy program that draws on the strengths of its innovation system to overcome the country’s weaknesses and address its challenges, seizing the opportunities offered by such a vast and richly endowed country. Currently, it also means working within the limitations imposed by austere economic policies. Against this background, the present study will set out how to develop a mission-oriented innovation policy program that can help Brazil generate smart, inclusive and sustainable growth.

1.2. Brazilian innovation policies in times of austerity

The outbreak of the global financial crisis in 2007 sent the world economy into its deepest recession in several generations. For a brief period, there was a consensus amongst many government leaders and policy makers that the state would have a key role to play in lifting economies out of the crisis, by promoting development and growth through active industrial policies. However, as public debts ballooned as a result of lower tax revenues and bank bailouts, this global consensus eroded and austerity policies became the most popular solution. The expectation was that, by getting the state out of the way, markets would promote growth again by themselves.

In short, as Box 1 illustrates, austerity became and remains the flavor of the day in many countries trying to resume economic growth, despite criticisms from the IMF (2012) and others.

Contrast the experience of countries that continue to grow. Germany, for instance, has increased its education, research and science budget by €10 billion per year since 2009, raising it to almost 10 percent of its GDP (FMER, 2013). Germany also has an active industrial policy agenda and has set the mission of transforming its energy system away from fossil fuels and nuclear energy, and into renewables. This 'energy transition' (*Energiewende* is a key part of Germany's innovation policy agenda, which can therefore be labeled as mission-oriented. Also, the investments of Germany's development bank KfW are oriented towards the fulfillment of particular missions, such as energy efficiency; promotion of high technology sectors; and the economic inclusion of former East Germany regions (Mazzucato and Penna, 2015b).

Box 1: Austerity and innovation

In the United States, the initial countercyclical *American Recovery and Reinvestment Act* of 2009 allocated USD 831 billion to be spent between 2009 and 2019. In 2011, budget sequestration put almost one-third of the US public R&D budget at risk for the following 10 years (USD 130 billion per year) (LaMonica, 2013). In Europe, the fiscal compact (which requires member states to have fiscal deficits that are only 3 percent of their GDP) has exerted pressure on counties to cut spending on areas like education and R&D. Spain – a critical case – has cut publicly funded R&D by 40 percent since 2009 (Buck, 2013). Between 2010 and 2015, the parliament in Greece enacted more than 10 austerity packages. In the United Kingdom, where the impact of austerity has been particularly severe on the welfare budget, the government agreed to at least 'ring-fence' the science budget, although in real (inflation-adjusted) terms, this has meant a 15 percent cut to research funding (Weir, 2014).

Source: Authors' elaboration.

Brazil was a relative laggard in the adoption of neoliberal policies in the 1990s and was again late to join the austerity trend. Austerity only became Brazil's key economic agenda in early 2015, a few months after the re-election of President Dilma Rousseff's government, which had previously promoted countercyclical and developmental policies. With the return of austerity policies came the usual cutbacks in the budgets of state institutions, including Brazilian agencies, enterprises, and banks that had been responsible for the emergence of internationally competitive sectors such as agribusiness, aerospace and deep-sea oil exploration.

Consequently, the new wave of active industrial policies in Brazil, which had begun under the first government of President Lula, is currently in check. Critics have condemned the 'overall failure' of developmental industrial policies, ignoring any instances where they succeeded. Some examples of success in Brazil include:

- The countercyclical public investments that prevented a bigger collapse of investment and GDP after the 2007 crisis.
- Embrapii, a 2013 initiative that has been relatively successful in promoting industrial innovation by fostering collaboration between firms and research institutes.
- BNDES investments in start-ups through the seed capital investment fund CRIATEC, first established in 2007 in partnership with a private sector fund manager; and
- PAISS, jointly led by FINEP and BNDES, the innovation program for the sugarcane sector that aimed to reposition Brazil amongst the leaders of second-generation ethanol production.

However, even the relative successes of Embrapii, CRIATEC, and PAISS – three cases where the public and private sectors had to act in synergy – are now being questioned due to the current imperative of austerity in economic policy in Brazil.

Against this backdrop, the challenge for Brazil is to enable its public institutions to play the key role in economic growth and development that public institutions have played in the development phase of all industrialized countries (Chang, 2002; Reinert, 2007). The challenge is indeed substantial: systemic mission-oriented innovation policies require clear articulation and coordination with other public policies. When macroeconomic policies are restrictive, they may undermine any explicit innovation and industrial policy efforts. Nevertheless, Brazil's current situation allows it to rethink its innovation policy agenda and sow the seeds for a virtuous cycle of socio-economic development. Brazil does have non-budgetary resources for R&D and innovation, such as the sectoral funds and BNDES funding that does not come from the Treasury. These funds may be used strategically to upgrade and restructure Brazil's national innovation system through specific mission-oriented programs. Furthermore, public perception of the importance of science, technology and innovation (STI) in Brazil is increasingly positive and optimistic, with a shared expectation of STI as

means to improve the quality of life.[1] This highlights the existing legitimacy for the state to promote public policies in the area.

Since public investments in R&D and innovation are known to be productivity-enhancing, creating well-paid jobs and with higher multiplier effects than other governmental expenditures (Tassey, 2013), such investments can help rebalance the public budget in the longer term by increasing future revenues. Such dynamic effects are often neglected in fiscal adjustment programs.

The main goal of this study is to suggest policy initiatives that will enable the Brazilian national innovation system (NIS) to become more *mission-oriented* through purposeful policies promoted by the state in direct partnership with the private sector. This report proposes *a process by which Brazil can identify its missions from the bottom up*. They can then be adopted as top-down public policies promoted by the Ministry for Science and Technology (MCTI) in coordination with other ministries and public agencies at all levels of government. Missions developed in this way will be more easily accepted and implemented by the many actors involved in the innovation process.

1.3. Overview and structure

The report is divided into six sections (including this introduction):

- Section 2 outlines the aims, objectives, and methodology of the study.
- Section 3 discusses the key theoretical concepts that underpin our analysis of the Brazilian system of innovation and on which we build our mission-oriented policy proposals.
- Section 4 reviews the literature on the Brazilian national system of innovation (NSI), mapping the strengths and weaknesses of its subsystems (the main actors in each subsystem are presented in Annex I), and identifying strategic public policy initiatives that can act as 'levers' for (or impediments to) *mission-oriented* policies.
- These features of the Brazilian NSI are further explored through interviews with relevant stakeholders of the Brazilian system of STI Section 5 analyzes the main findings of the interviews while the interview structure and list of interviewed institutions are reported in Annex II and III, respectively.
- Section 6 concludes, drawing on the theoretical discussion, contextual analysis, and interview findings to propose mission-oriented innovation policy lines of action for Brazil.

[1] Results from the survey "Percepção Pública da C&T no Brasil 2015" (CGEE/MCTI, 2015); available at: http://percepcaocti.cgee.org.br/; accessed on 10/11/2015.

2. Aims, specific objectives, and methodology

2.1. Aims

The study has two interrelated aims:

a) To provide an overview (a 'map') of the Brazilian system of innovation, identifying its key strengths and weaknesses; and
b) To develop proposals for establishing mission-oriented programs for the development and improvement of the Brazilian system of innovation.

To achieve (a), the study specifies certain objectives and a methodology that will differentiate it from the existing literature.

2.2. Specific objectives

The mapping of the Brazilian system of innovation will be carried out through:

- Reviewing the latest literature on the Brazilian system of innovation; and
- Interviewing key actors in the Brazilian system of innovation, from the private sector (production and innovation subsystem), the public sector (policy and regulation), and the research sector (knowledge production), in order to understand their perceptions of the current system.

The proposals for making the Brazilian system of innovation more mission-oriented will draw on the findings from this mapping exercise, combined with theoretical concepts from the literature on the entrepreneurial (developmental) state and on mission-oriented policy. The objectives are:

a) To propose *principles* through which to structure a mission-oriented policy agenda, taking account of societal challenges; and
b) To outline the specific opportunities, based on the Brazilian innovation system's strengths that can be used to build different mission-oriented policy programs.

2.3. Methodology

The study employed a qualitative research methodology (Yin, 2003; George and Bennett, 2005; Flyvbjerg, 2006). Qualitative research methods are appropriate for studying complex contemporary phenomena and are particularly suitable for addressing *what* and *how* questions (as opposed to quantitative questions such as *how many*, *how much*, or *to what extent*). The present study focused on the following questions: *What are the system's strengths and weaknesses? How do these translate into opportunities and threats? What are the key challenges and missions to address? How can the Brazilian system be*

progressively transformed into a mission-oriented system of innovation? How can this be done given current politico-economic limitations?

2.3.1. Literature review

The literature review summarized and assessed contemporary studies of the Brazilian system of innovation. The aim was to provide an account of the evolution and status of the system: how it developed, its main strengths and weaknesses, and the key institutions and actors in the public, private, and academic sectors.

We reviewed the English and Portuguese literature on the Brazilian innovation system. Our sample of studies was drawn from keyword searches in academic databases (*Thomson Reuters' Web of Knowledge* and *Google Scholar*), complemented by citation analysis of selected studies (identifying other relevant works that are cited by, or cite, a selected study). We also drew on policy and research reports.

2.3.2. Interviews

The interviews sought to develop further insights into the specific findings and topics identified in the literature review, whilst also exploring the mission-oriented innovation policy paradigm. The aim was to produce a detailed understanding of how particular agents perceive the core strengths and weaknesses of the Brazilian innovation system. The interview findings were triangulated with the findings from the literature review to develop the study's proposal for a mission-oriented system of innovation in Brazil.

We adopted a semi-structured interview method, conducted on the basis of a topic guide, made up of open-ended questions, which provide a loose script that can be modified depending on the interviewee's answers. The key advantage of a semi-structured interview approach is its flexibility: it leads to the discovery and elaboration of new information and allows the interviewer to explore a topic in more detail, depending on the interviewee's knowledge and capabilities. A good semi-structured interview template should include questions that are open-ended (that is, they should not lead to yes/no answers), neutral (they should not influence or bias the answer), sensitive to the interviewee's characteristics, and understandable to the interviewee. For the present study, our interview template covered four broad topics, derived from the important theoretical aspects that we highlight in section 3. Each topic was made up of

specific open-ended questions and prompts that encouraged respondents to explore specific points in their answers (see Annex II). The topics were:

i. The Brazilian innovation system: perceived strengths and weaknesses
ii. Public-private interactions and networks in the Brazilian innovation system
iii. STI policies: importance of different instruments
iv. Risks and rewards: sharing successes and failures; the issue of inequality and other societal challenges

The semi-structured interview template was used with interviewees from the three subsystems of Brazilian system innovation: private sector (business executives), public sector (policy makers and officials), and the academic community (researchers). In contrast to sampling in quantitative research, which is meant to be representative and statistically significant (through random selection), sampling in qualitative research is purposive. In the case of interviews, respondents are selected because they may generate useful data for the project. In this study, we adopted a stratified purposeful sampling strategy, whereby we selected respondents who may illustrate the perception of the particular subgroups of interests (that is, the public sector, the business sector, and academia).

The mapping of the Brazilian innovation system, through the literature review, enabled us to identify the key public agencies and research institutions (including universities), from which we selected this part of our sample of interviewees. We conducted 17 interviews with 23 representatives from the public sector, 18 of whom hold first-tier positions in ministries, agencies, and research institutions (see Annex III, which details the list of interviewees).

The aim was to interview an equal number of representatives from the private sector, but this proved infeasible given the low response rate from companies that were contacted. For this reason, the evidence gathered through interviews with a restricted number of private sector representatives was triangulated with evidence gathered from the interviews with public sector representatives in order to cross-check information and data. We conducted interviews with top executives from six private sector institutions (four industrial firms, one private investment fund, and one industry association). We also used the same triangulation strategy with the evidence gathered through two interviews with six representatives from quasi-governmental institutions at the interface between the private and public sector.

2.3.3. Analysis

All interviews were digitally recorded (with the interviewees' consent) and transcribed. Interviewers also took notes during each interview to facilitate the identification of key points made by respondents. The analysis of the data collected through the interviews was based on both the transcriptions and annotations.

The data collected through the interviews was collated in tables divided into categories that reflect the same general themes and questions as the interview structure. The data was further analyzed to identify recurring issues, topics, and ideas: for example key strengths and weaknesses, and the main challenges (missions) for the Brazilian innovation system to address. These recurring issues, topics, and ideas were summarized with the aid of the quantitative analysis software *NVivo*. To guide the reader through our analysis, we present 'word clouds' depicting the most commonly recurring issues, topics, and ideas (the top 20 words mentioned in all interviewees' answers by topic). The software automatically generates the word clouds, presenting the words that appeared more often in larger font and more centrally. We removed irrelevant words (such as 'this' or 'that') or words that biased the results because they were precisely the topic under discussion (such as 'good' or 'system').

Through the interviews it was possible to identify illustrative examples of successful or failed contemporary innovation policy initiatives in Brazil (including some that seem to include important mission-oriented features). To validate the findings from the interviews and deepen our analysis, these cases were further triangulated and compared with the findings from the literature review. The final step of our analysis was to develop the proposal for the transformation of the Brazilian innovation system into a mission-oriented system, based on the findings from the interviews and the literature review.

3. Theoretical background

In this section, we present the theoretical foundation and stylized facts upon which we base our analysis of the Brazilian innovation system (section 4) and which guided the semi-structured interviews (the findings of which are analyzed in section 5). We draw on the same principles to develop our recommendations in section 6. To guide the reader, we highlight key concepts throughout the section.

3.1. Evolutionary economics, innovation dynamics and national systems of innovation (NSI)

The first models of economic growth, such as those that follow in the footsteps of Roy Harrod (1939) and Evsey Domar (1946) and Nobel laureate Robert Solow (1956), did not explicitly consider technology and innovation. In contrast, the evolutionary economics approach, pioneered by Nelson and Winter(1982) building on the work of Joseph Schumpeter (1934 [1912]; 1942), delved inside the 'black box' of the firm in order to understand how innovation occurs and how it affects competition and economic growth.

In the standard neoclassical approach to the economics of the firm, models start with the assumption (among others) of the 'representative firm'. In contrast, the evolutionary approach recognizes that firms are different from one another. It borrows from biology the notion of *variation*, *selection*, and *retention*:

- processes of innovation, marketing, and other active strategies of differentiation confer advantages on some firms and not others, leading to *variation* between firms;
- once variation is created, some firms are selected by market forces and others are not (*selection*);
- finally, selected variations diffuse throughout the economy through means such as competition and imitation (*retention*).

In contrast to the usual survival-of-the-fittest perspective, selection sometimes occurs due to the effects of increasing returns (for example from first-mover advantages, which then 'stick'), or to entry/exit barriers (such as those related to the level of capital investment or property rights/proprietary technologies), or even to the effects of policies that might favor certain types of sectors, firms, or activities. Therefore, the institutional environment – including the regulatory framework and both formal and informal political and social institutions – acts as a crucial part of the selection mechanism (Dosi, 1988; Geels, 2014).

Evolutionary economists have also identified the innovation process as having three important characteristics (Dosi, 1988; Lazonick, 2011). Firstly, it is highly *uncertain*, which means that the odds of success cannot be inferred in advance, so that usual risk management techniques are of little use to innovators. Secondly, it is *cumulative*; that is, what has been learned and produced in the past contributes to what is done in the present and in the future. Thirdly, it is a *collective* enterprise, with different types of agents playing a part, and sharing the risk, including scientists, workers, managers, financiers, consumers and even policy-makers.

Principle 1: Innovation policy must build on the key characteristics of how innovation comes about: it is *uncertain*; *cumulative*; and *collective*. *Uncertainty* means that agents concerned with innovation cannot calculate in advance the odds of succeeding – that is, results are *unknown* – and therefore in order to succeed will have also to *accept occasional failures and detours* from planned routes. *Cumulative* means that agents need to be patient and act strategically to accumulate competences and capabilities (learn) with a view to the long run. *Collective* means that all agents need to work together and thus bear certain degrees of risk; they are therefore entitled to also share the rewards. Imbalances in this 'risk-reward nexus' may result in inequality (Lazonick and Mazzucato, 2013).

The first innovation models were mainly linear (Godin, 2006). In the supply–push version of the model, innovation proceeded from basic research, through applied research and development (including prototyping and initial market tests), to production and diffusion. In the demand–pull version, demand and user (market) needs 'pulled' the innovation efforts. The linear model was criticized in the late 1980s because the innovation process did not always proceed through a linear supply–push or demand–pull trajectory. Within the firm, innovation proceeded along a development path characterized by trial and error, iteration and feedback loops.[2] Outside the firm, the innovation process appeared to be increasingly dependent on specific institutions and their interdependences. The innovation process was therefore seen as '*systemic'* rather than '*linear'*.

The insights from the evolutionary economics perspective contributed to the development of the '*systems of innovation*' approach (see e.g. Lundvall, 1992; Freeman, 1995). Systems of innovation have been defined as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge" (Lundvall, 1992, p. 2). In the systems view,

[2] See for example Kline and Rosenberg, 1986.

firms are embedded in a national system of institutions. It is not so much the quantity of R&D in a country that matters, but how it is distributed in the form of complementary assets, strategic institutions, and organizations. What matters is the circulation of knowledge and its diffusion throughout the economy, emphasizing the collective nature of successful innovation. The systems view also emphasizes the importance to the innovation process of feedback loops between markets and technology, applications and science, policy and investments.

While the systems approach first focused on the *national* level, other studies looked at *regional* and *local* systems of innovation (see Box 2). Cultural, geographical, and institutional proximity facilitates transactions between local or regional economic actors, and, more importantly, facilitates learning and the exchange of tacit knowledge. Studies focusing on industrial districts and local systems of innovation have shown that the conventions and other socio-institutional features of a region can affect technological change at a national level (Lemos, 2003).

Box 2: Local systems of innovation: Brazil's *Arranjos Produtivos Locais* (APL)

In Brazil, the importance of the collective dimension in production and innovation has been reflected in economic policy making. In particular, policies to promote technological and industrial development have recognized that the agglomeration of firms and the benefits generated by their collective interactions can contribute to sustainable competitive advantage (Cassiolato et al., 2003). The concept of local productive arrangements (in Portuguese *Arranjos Produtivos Locais*), or APLs, plays an important role in national development policy and STI policy. APLs are seen as a means for targeting a range of policies with different goals on different types of economic actors. These local arrangements are cited in development plans in relation to traditional sectors, capital-intensive industries and knowledge-intensive activities. Although APLs play a major role in traditional sectors, they are increasingly being used in knowledge-intensive areas as well, involving initiatives such as technology parks and with close links to national innovation policy.

Source: Authors' elaboration.

The systems approach to innovation provides an alternative view of the role of the state in the economy and in the innovation process, beyond fixing market failures (that is, situations where the market fails to efficiently allocate resources). Instead the state's role in fixing system failures is emphasized (Woolthuis *et al.*, 2005). System failures are defined as the ineffectiveness of a

given system of innovation to perform its core functions, which include fostering entrepreneurial activities, learning, knowledge diffusion, market formation, and resource mobilization (Hekkert *et al.*, 2007; Negro *et al.*, 2007).

However, a focus on remedying system failures, while certainly more insightful than the narrow focus on market failures, may not in itself be sufficient. Policies based on the market failure perspective are often limited to addressing the issue of public goods, such as the knowledge that stems from research efforts, or the funding of entrepreneurial firms that do not attract finance due to information asymmetries or a lack of collateral. Such policies result in a 'science-push' bias in innovation policies. Any public investments that target issues beyond those that represent market failures lead to criticisms of 'crowding out': that is, the public sector would be moving into areas where the private sector could be investing (the criticism sometimes does not take into account that the area would not exist in the first place if the public sector would not create it through mission-oriented policies).

Policies focused on correcting system failures are often *horizontal*, which means they try to establish an institutional system conductive to innovation (for example, policies that seek to create an entrepreneurial culture, or to improve education), and still rely on the market for the direction of change. As we argue below, policies based on a *mission-oriented* policy will require all these types of policies – and more.

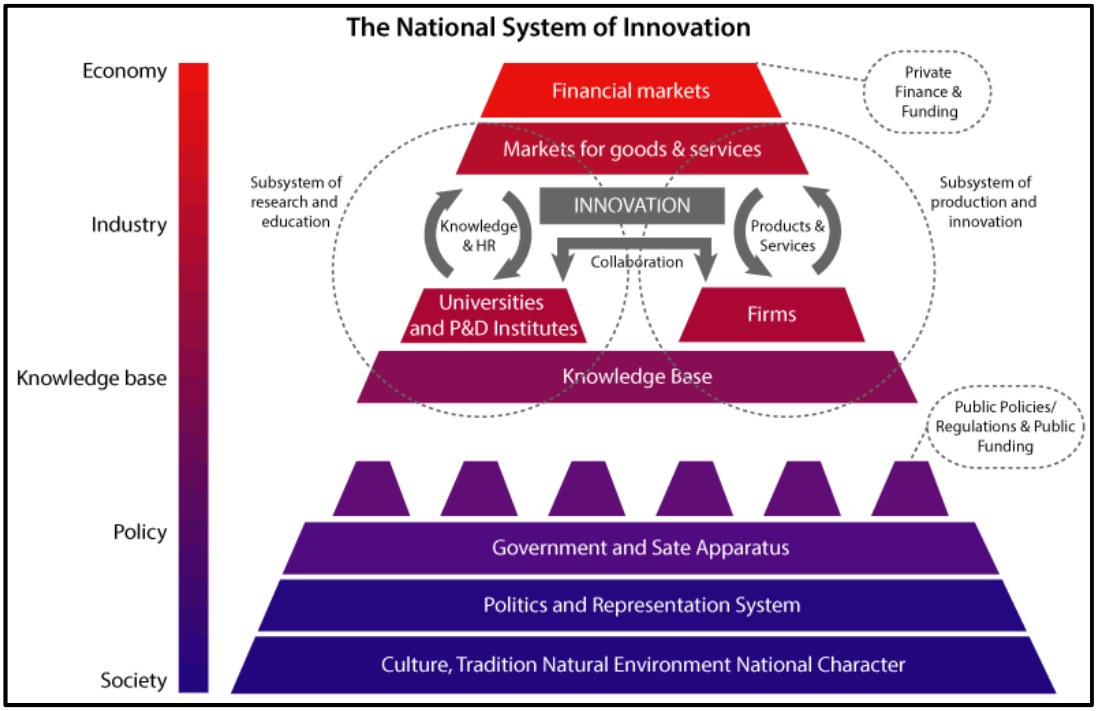
Principle 2: Policies based on a mission-oriented perspective are *systemic*, employing but going beyond science-push instruments and horizontal instruments. Mission-oriented policies employ the array of financial and non-financial instruments to promote the accomplishment of the mission across many different sectors, setting concrete directions for the economy, and deploying the necessary network of relevant public and private agents.

Finally, a *narrow* perspective on systems of innovation can be differentiated from a *broad* perspective (Cassiolato, 2015): the *narrow* perspective is focused on the science and technology subsystem (which includes capacity-building, training and formal education, plus science- and technology-related services) and its relationship with the production and innovation subsystem (where firms mainly operate). The *broad* perspective includes other subsystems and contexts: for example the subsystems of policy, promotion, representation and financing; demand (market segments); and the (geo)political and socio-economic context.

Following recent analyses of the Brazilian system of innovation (by Koeller and Gordon, 2013; Cassiolato *et al.*, 2014; Cassiolato, 2015), and in line with the definitions and conceptualizations of Freeman (1987) and Lundvall (1992, 2010), we have adopted a broad perspective to characterize the system. Figure 1 depicts a generic national system of innovation. Each level sustains and influences the other. Although the depiction implies a linear hierarchical relationship, in reality, there are mutual causations and flat hierarchies. Thus, there is no unidirectional causality, for example, from policies or science to market strategies and innovation. Nor is there an implication that any layer or subsystem is more important than others.

At the base of a national innovation system is the socio-economic, political, cultural, and environmental context. The next layer up is the government and state apparatus, which is responsible for public policy making and funding. This is the subsystem of public policies/regulations and public funding.[3] Two other subsystems are the subsystem of production and innovation, which is populated mainly by business firms and their R&D labs, and the subsystem of research and education, which includes research and technology institutions (including universities and public R&D labs, but also other education organizations).

Figure 1: Representation of a generic national system of innovation



Source: Authors' construction based on diagram prepared by the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT, 2002).

[3] In our analysis of the Brazilian NSI in section 4, we separate the subsystem of public policy and public funding into two, in order to discuss the Brazilian subsystem of public funding together with private finance/funding.

These two subsystems operate on a broad knowledge base, and may collaborate with each other. Firms in the innovation and production subsystem engage in market exchanges selling/buying goods and services to/from consumers/suppliers. Universities and research institutes engage in market exchanges for knowledge and human resources. Both of these subsystems may also draw on financial markets for funding and investments. We use this generic representation to map the Brazilian system of innovation in section 4.

Principle 3: A *broad* perspective on the national system of innovation identifies four subsystems: (i) public policy and public funding; (ii) research and education; (ii) the subsystem of production and innovation; and (iv) private finance and private funding. While all subsystems are theoretically of strategic importance, the subsystem of public policy and funding has traditionally led the process of socio-economic development and technical change.

3.2. Mission-oriented policies and the developmental entrepreneurial state

Recent research has shown that the system of organizations and institutions reflects the crucial and leading role of the state. Historically, the state has led the process of industrial development by developing active strategies for technological advance in priority areas (Chang, 2002; Perez, 2002; Reinert, 2007; Mazzucato, 2013; Weiss, 2014). This type of developmental state does not seek to address a certain type of failure, whether market or system failure. Instead, it seeks to *create and shape* markets and systems. This is often done through a specific type of initiative; namely*, mission-oriented policies*. Mission-oriented policies require the state to have (or establish) particular competences. In other words, they require state and policy capacity to implement them (Karo and Kattel, 2015).

Principle 4: In order to stimulate the innovation process by shaping and creating technologies, sectors, and markets, new relationships must be developed and more trust must be created. The state must galvanize the interests of relevant actors and organize itself so that it has the 'intelligence' to think big and formulate bold policies that also create a sense of ownership amongst diverse public, private, and academic stakeholders. It is also crucial to be able to implement the policies by coordinating the efforts of this network of stakeholders through the state's convening power, brokering of trust relationships, and the use of targeted policy instruments.

Because innovation is extremely uncertain, the ability to experiment and explore is key for a successful entrepreneurial state (Hirschman, 1967; Rodrik, 2004; Mazzucato, 2013). Therefore, a crucial element in organizing the state for its entrepreneurial role is *absorptive capacity* (Cohen and Levinthal, 1990) or *institutional learning* (Johnson, 1992). Governmental agencies learn in a process of investment, discovery, and experimentation that is part of mission-oriented initiatives.

Other authors have referred to this experimentation and learning process as "smart specialization" (Foray *et al*, 2009). However, smart specialization is used in connection with a market failure framework, so that it is seen as a discovery process for the identification of bottlenecks, failures, and missing links (that is, market-failures or market gaps). Smart specialization has not been employed in connection to a systemic perspective on innovation policies.

Principle 5: Systemic mission-oriented policies must be based on a sound and clear diagnosis and prognosis (foresight). This requires not only require the identification of missing links, failures and bottlenecks – the weaknesses or challenges of a national system of innovation – but also identification of the system's strengths. Foresight is necessary in order to scrutinize future opportunities and also identify how strengths may be used to overcome weaknesses. This diagnosis should be used in devising concrete strategies, new institutions and new linkages in the innovation system (Mazzucato, 2015). It may also be necessary to 'tilt' the playing field in the direction of the mission being pursued rather than 'leveling' it through such means as technologically neutral policies (Mazzucato and Perez, 2015).

Work on the developmental state has revealed the importance of the visible hand of the state in industrialization and technological change (Wade, 1990; Amsden, 2001; Chang, 2002). Latin American countries are familiar with the developmental approach. Structural economists from the Economic Commission for Latin America and Caribbean (ECLAC) were pioneers in the conceptualization of development economics and the active policies promoted by the state (see Box 3).

More recently, the developmental state literature has emphasized the developmental *network* state as key; that is, a decentralized network of state agencies that can foster innovation and development. Significant attention has been paid to the role of large agencies or institutions (such as DARPA or the NIH in the US, or MITI in Japan) in mission-oriented projects. Until recently, however, less focus was placed on the roles of a broader network of institutions,

actors, strategies and agencies, and the intelligence distributed amongst them (Freeman and Perez, 1988; Perez, 2002). In order to establish a feasible mission for a national system of innovation, it is crucial that the state can identify this 'distributed intelligence' and in particular the capabilities and competences of the *public* sector, the *private* sector, and the *academic/research* sector.

Many successful cases of innovation and technology policy strategies have been carried out by networks of decentralized public institutions that have focused not on singling out and supporting individual 'national champion' firms, but on establishing an environment conductive to a constellation of innovative firms (O'Riain, 2004). This has been the case in East Asia, Finland, Israel, Taiwan, and even in Silicon Valley and other initiatives in the USA (Block and Keller, 2011; Weiss, 2014). Such policies have covered a wide range of systemic measures, including financial instruments in support of R&D, innovation and diffusion of products, training, support for marketing and exports, funding programs (including early-stage venture capital), networking and brokerage services, building of facilities and clusters (for example, science and technology parks), public procurement, and fostering industrial ties.

Box 3: The Developmental State and the Structuralist School of Economics

Prebisch (1950) and Singer (1950) argued that the gains from international trade were unevenly distributed between developed and developing countries. Other authors from the Structuralist School discussed the relationship between technical change and the evolution of capitalism. Furtado (1961) established a direct relationship between economic development and technological change, stressing that development is based on the accumulation of knowledge and the incorporation of technologically more sophisticated sectors. Thus, overcoming underdevelopment would call for structural change away from primary products, incorporating the benefits of the second industrial revolution.

An implication of the Structuralist analysis was the need for an active state that promotes changes in economic structure, in order to overcome the strong static comparative advantages in favor of primary activities and the high costs and risks involved in the 'creation' of new industrial sectors.

The Brazilian government was directly influenced by these arguments and promoted major structural transformations during the import substitution industrialization phase (from the 1930s until the late 1970s). This period was marked by a combination of direct state action, major risk-taking in new areas, building up the necessary technological and managerial capacities and investing in all stages of the innovation process (especially in heavy industry,

infrastructure, public services, health, and some high-tech sectors). To a certain extent, recent industrial policy plans promoted by Brazil since 2003 have been influenced by this developmental state rationale.

Source: Authors' elaboration.

Not all networks of decentralized institutions have been driven by a technological mission, but this has been the case with two of the most successful cases of mission-oriented initiatives in the US; namely the networks fostered by DARPA (security mission) or the NIH (health). In the case of Japan (through MITI) and East Asia, in general, the implicit mission was industrial development and 'catch-up' (Chang, 2002).

Principle 6: To fulfill a mission, a country requires what we call an entrepreneurial state (Mazzucato, 2013). This concept encapsulates the risk-taking role the state has played in the few countries that have managed to achieve innovation-led growth. It is through mission-oriented policy initiatives and investments across the entire innovation process – from basic research to early-stage seed financing of companies – that the state is able to have a greater impact on economic development.

3.3. A mission-oriented approach to innovation policies

The kind of broad-based innovation policy that is driven by, for example, a 'security' motive has been dubbed mission-oriented because such policies aim to achieve specific objectives (Ergas, 1987; Freeman, 1996). Rather than just facilitating innovation through horizontal policies that level the playing field, with the trajectory being left to markets, such policies include explicit technological and sectoral *directions*. Such innovation policies are not a passive reaction to market failures, but an active choice to achieve a vision or *mission* (Mazzucato, 2015). Understanding the role of the public sector in innovation within a mission-oriented framework is a different analytical exercise than the one derived from the market failure framework (Mazzucato and Penna, 2014; 2015a).

Principle 7: The state must be able to learn from experience in mission-oriented innovation policy. In a market failure framework, *ex-ante* analysis aims to estimate benefits and costs (including those associated with government failures) and *ex-post* analysis seeks to verify whether the estimates were correct and the market failure successfully addressed. A mission-oriented framework requires continuous and dynamic monitoring and evaluation throughout the innovation policy process.

In its most general form, the mission-oriented framework differentiates between public policies that target the development of specific technologies in line with state-defined goals ('missions') and those that aim at the institutional development of a system of innovation (Ergas, 1987; Cantner and Pyka, 2001). This framework helps us understand the greater breadth of activities that public spending fosters.

Mission-oriented policies feature both in security-led missions (driving technologies in the defense and energy sectors) and in such diverse areas as health and agriculture (Mowery, 2010; Sampat, 2012; Wright, 2012). Also, the current active role of the public sector in tackling renewable energy investments can be seen as a new mission in relation to the green economy (Mazzucato and Penna, 2015b). Other new missions include addressing such 'grand societal challenges' as the ageing/demographic crisis, inequality, and youth unemployment (European Commission, 2011). In fact, these challenges – which can be environmental, demographic, economic or social – have entered innovation policy agendas as key justifications for action, providing strategic direction for funding policies and innovation efforts.

Consequently there has been a call in recent years for a return to mission-oriented policies as a way to address grand societal challenges (Mowery *et al.*, 2010). In the past, missions were often related to a well-defined outcome, such as putting a man on the moon, which entailed mostly technological challenges. However, Foray *et al.* (2012) claimed that modern missions are more complex because there are fewer clear technological challenges and outcomes are less clearly defined. Contemporary missions aim to address broader challenges that require long-term commitment to the development of many technological solutions and "a continuing high rate of technical change *and* a set of institutional changes" (Freeman, 1996, p. 34). One could add that these challenges also require changes at the societal/national systems level. The so-called Maastricht Memorandum (Soete and Arundel, 1993) provides a detailed analysis of the differences between old and new mission-oriented projects (Table 1):

Table 1: Characteristics of old and new mission-oriented projects

Old: Defense, nuclear, and aerospace	**New: Environmental technologies and societal challenges**
Diffusion of the results outside of the core of participants is of minor importance or actively discouraged.	Diffusion of the results is a central goal and is actively encouraged.
The mission is defined in terms of the	The mission is defined in terms of

number of technical achievements, with little regard to their economic feasibility.	economically feasible technical solutions to particular societal problems.
The goals and the direction of technological development are defined in advance by a small group of experts.	The direction of technical change is influenced by a wide range of actors including government, private firms and consumer groups.
Centralized control within a government administration	Decentralized control with a large number of agents involved.
Participation is limited to a small group of firms due to the emphasis on a small number of radical technologies.	Emphasis on the development of both radical and incremental innovations in order to permit a large number of firms to participate.
Self-contained projects with little need for complementary policies and scant attention paid to coherence.	Complementary policies vital for success and close attention paid to coherence with other goals.

Source: Slightly modified version of table 5 in Soete and Arundel (1993, p. 51).

Although the memorandum specifically focuses on mission-oriented programs that tackle environmental challenges, its analysis applies to other contemporary challenges (water and food supply, energy efficiency and security, disease, well-being, demographic change, etc.). This is because all of the challenges present similar characteristics, particularly the fact that new technological solutions to address them will need to replace incumbent technologies, and therefore require long-term commitments from both public and private agents. That is, the diffusion of solutions to a broad base of users is key. One of the most pressing contemporary challenges, particularly for a country like Brazil, is the need for *inclusion* of vast portions of the population (and of entire regions) in the innovation process and the socio-economic system as a whole, in order to tackle the issue of inequality.[4]

The six characteristics of contemporary missions identified in Table 1 – diffusion of technologies, economic feasibility, shared sense of direction, decentralized control by (strategic public) agencies, development of both radical and incremental innovations, and enabling complementary policies – are of pragmatic importance for the promotion and implementation of mission-oriented policies.

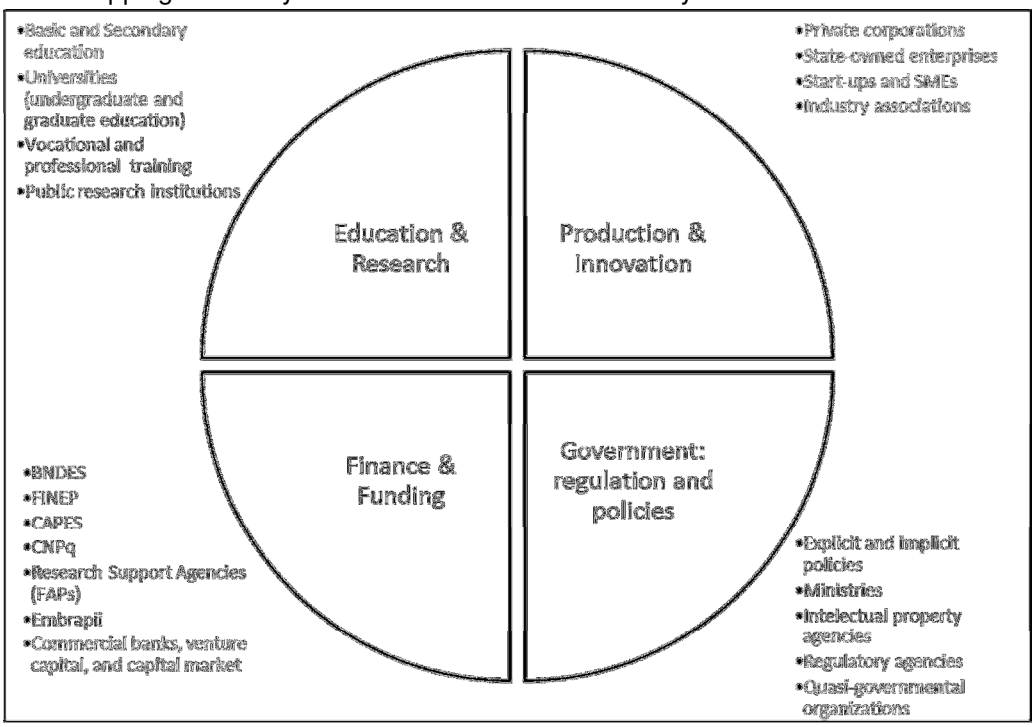
[4] A recent and flourishing body of literature has explored the connections between innovation and systems of innovation and social inclusion. Issues of social development are being studied and targeted in policy action under the heading of 'social innovation'. Other recent correlated terms are 'innovation for the bottom of the pyramid' and 'pro-poor innovations'. With respect to sustainability, a minority of contributions seeks to expand the concept of sustainability to a social dimension (Cozzens and Kaplinsky, 2009; Soares et al. 2014).

We draw on this characterization of contemporary missions to formulate our policy proposal in section 5. It highlights the need to make a precise diagnosis of the technological, sectoral, or national system innovation that the mission-oriented policy aims to transform or create. As we will argue, the alignment of different types of capabilities is key for the success of any mission-oriented policy program.

4. Mapping the Brazilian innovation system: subsystems, actors, and organizations

In this section, we discuss the four subsystems of the Brazilian national system of innovation. These are: (1) production and innovation; (2) research and education; (3) finance and funding (public and private); and (4) policies and regulations.[5] With regard to the last of these subsystems, we identify and discuss in detail strategic public policy initiatives that are explicitly, implicitly, or complementarily related to science, technology and innovation, which can act as levers for (or impediments to) *mission-oriented* policies. Figure 2 summarizes this mapping of the Brazilian NSI, indicating the actors and organizations upon which our discussion focuses (a brief description of these actors is presented in Annex I).

Figure 2: Mapping the subsystems of the Brazilian National System of Innovation



Source: Authors' construction.

4.1. Subsystem of production and innovation

Until the mid-1950s, the Brazilian economy specialized in the production of commodities, with cotton, sugar, and coffee as the main produce. After World War II, the federal government promoted an industrialization process through

[5] We have not mapped the national context (politics, culture, natural environment, etc.) as it is beyond the scope of this analysis. Nevertheless, some of these aspects came up in the interviews as strengths/weaknesses of the Brazilian system of innovation (see section 5).

import substitution, actively contributing to the institutionalization of the Brazilian system of innovation. The state-led import substitution strategy enabled the country to establish domestic sectors producing non-durable consumer goods, then durable consumer goods, followed by basic intermediary goods, and finally capital goods. By 1980, Brazil's industrial structure was almost complete, presenting "a high degree of inter-sectoral integration and product diversification" (Koeller and Cassiolato, 2011, p. 38).

From 1980 onwards, Brazil experienced a continuous decline in the share of manufacturing in its GDP, a process initially triggered by macroeconomic difficulties which prevented the continuation of the import substitution effort. Short of foreign capital and investment from multinational corporations, the state was unable to continue to invest in the industrialization process, while private agents became creditors of the state, buying treasury bonds that offered high yields. In the 1990s, the liberalization and privatization process led to considerable restructuring of the Brazilian industrial base. Domestic firms' reaction to the opening up of the economy at an uncompetitive exchange rate was very defensive. To survive, firms focused on cutting costs instead of investing in R&D and innovation. The short-term focus led to adverse long-term results, such as lower diversification and lower technological intensity of the industrial base (Laplane, 2015).

Therefore, after a successful industrialization process that led to a diversified industrial base, Brazil experienced a decline in the contribution of the industrial sector in the economy. Whilst the decline in manufacturing relative to GDP (with the increase in the share of services) is a trend common to many countries, Brazil has seen a specialization in *low-tech* industrial sectors (Carvalho and Kupfer, 2011). Furthermore, the commodity price boom triggered by China's high-growth strategies increased the value of Brazil's exports of agricultural and mineral commodities, further reducing the share of manufacturing in the economy (Kregel, 2009).

As a result of these broad trends, the Brazilian production and innovation subsystem can be characterized as follows (Cassiolato, 2015; Castro, 2015):

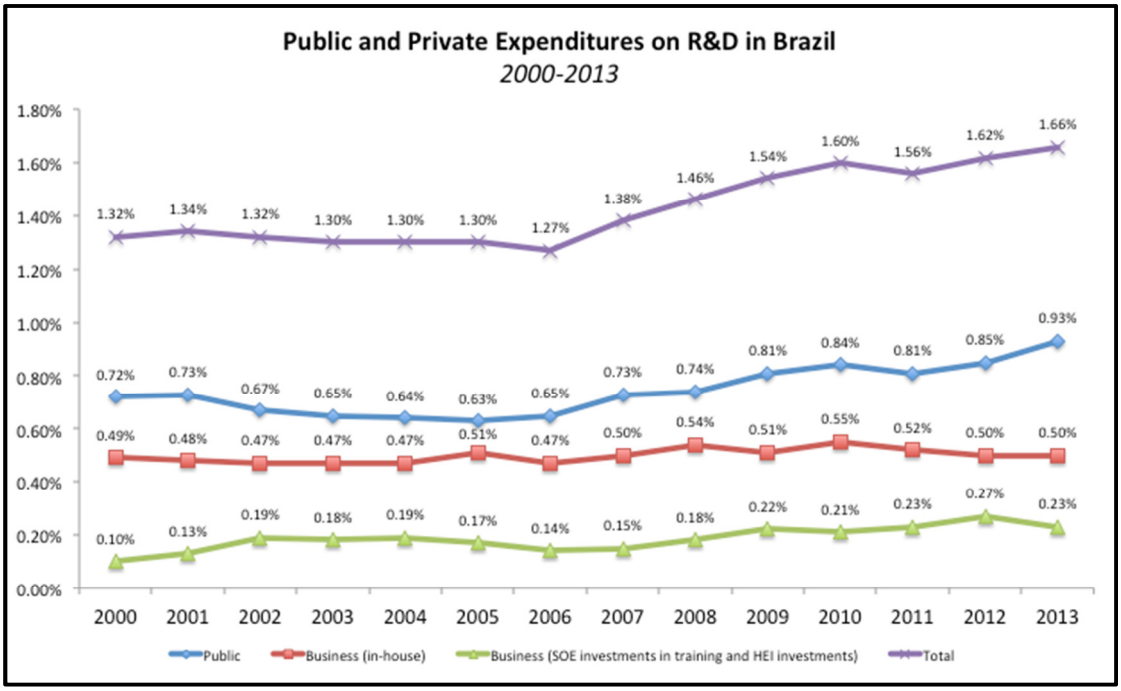
- Firms have a very low propensity to innovate[6], which means that business expenditure on R&D (BERD) is also very low, reaching just

[6] There is a literature that tries to access whether this low propensity to innovate is due to the origin of capital: in Brazil, most firms in 'high tech' sectors are subsidiaries of multinational corporations, which would tend to invest in R&D and innovation at home, and only carry out R&D activities to adapt products and services to local conditions of demand. See Zucoloto (2009) for a review of the literature and empirical analysis of Brazil's innovation surveys data.

0.50 percent of GDP in 2013, excluding investments in training by state-owned enterprises and in postgraduate activities by higher education institutions (Figure 3). Furthermore, data from the Brazilian business R&D and innovation survey (the 'Pintec')[7] showed that only 35.56 percent of surveyed firms declared that they carried out innovations between 2009 and 2011. While higher than the 32.52 percent innovation rate from 1998–2000, this is lower than the 38.11 percent of the previous survey from 2006 to 2008. Moreover, Brazilian firms typically invest more in process innovation, through the acquisition of (imported) machinery and equipment, than in product innovation. Just 3.66 (2.12) percent of firms carried out product (process) innovations that were new to the Brazilian market (de Negri and Cavalcante, 2013).[8]

- Firms also have very low expenditures on training and educational qualifications (less than 0.10 percent of net income). Expenditures in these areas represent a small fraction (less than 3 percent) of the already low expenditure on innovative activities.

Figure 3: Public and Private Expenditures on R&D in Brazil



Source: MCTI.

[7] Two aspects should be mentioned as to the completeness of the information provided by Pintec. Firstly, the research focuses almost exclusively on activities of the manufacturing industry. Only in the two most recent versions? were some segments of services such as telecommunications, R&D, information technology and software included. Secondly, the survey considers only companies with more than ten employees, which excludes a large number of micro enterprises.

[8] Despite these disappointing results, the 2011 Pintec also showed an increase in the contribution of 'high-tech' sectors to business expenditures on R&D relative to sales (de Negri and Cavalcante, 2013), which highlights the aforementioned heterogeneity of the Brazilian industrial base.

- Whilst Brazil ranked 12th in 2013 in terms of worldwide patent applications by applicant's country of residence [9], the absolute number of patents (4,959 patent applications) is still very low in comparison to the top countries (704,936 by China, which held first place; 287,831 by the United States, which stood second) or even compared to Italy, which ranked 11th (8,307 patent applications).

- In general, firms do not systematically engage in cooperation with other firms and research institutions.

- Note that, in the case of Brazil, accusations of public spending crowding-out business resources seems to be valid for the years 2000-2006, when there is an apparent negative correlation between public R&D investments and business R&D investments. However, since 2007, there seems to be a change in the relationship between public and business R&D investments, revealing a complementary relationship between the two variables, with both indicators increasing at the same time (positive correlation)[10].

These results do not capture the full picture of the Brazilian subsystem of production and innovation, because some sectors are highly dynamic. This is the case with the agribusiness sector, whose growth and modernization made Brazil a world leader in meat and soy exports. This was made possible thanks to "a greater systemic integration between economic agents, especially suppliers of machines and equipment and of inputs and fertilizers, with research institutes and with agricultural productive units" (Cassiolato, 2015, p. 276). Brazil has a well-structured national and regional system of agrarian research anchored by the genetic research carried out by EMBRAPA, a public R&D agency. Such a system led to positive spillovers in sectors such as chemicals (for fertilizers and pesticides), agrarian machines, and services (logistics), as they were required to develop new processes and technologies to meet the demands of agribusiness.

The Brazilian service sector also displays greater dynamism and a higher propensity to innovate than is shown through official statistics. In particular, Brazil is one of the world leaders in bank automation, an activity that emerged from the need to cope with very high inflation rates in the 1980s, and which

[9] World Bank data, available at: http://data.worldbank.org/indicator/IP.PAT.RESD (Accessed 15/10/2015)
[10] These initial findings come from an unpublished PhD Research by Mr Marco Carreras (SPRU, University of Sussex), who is studying the crowding out hypothesis in the case of public investments in R&D in Brazil.

paved the way for the development of a software industry. By the year 2000, Brazil represented the seventh-largest world market in terms of domestic software sales. While still relatively low, the share of the software industry in GDP trebled from 0.27 percent in 1991 to 0.71 percent in 2001 (Cassiolato, 2015, p. 277). Firms in this industry, many of them small and medium-sized enterprises (SMEs), display a higher propensity to innovate than the average; a higher level of expenditures on R&D and training; and more cooperation with universities and research institutions.

A third sector that has shown more innovativeness and dynamism is the **energy sector**, anchored by the activities of the state-owned oil enterprise Petrobras. The company has its own specialized R&D center (CENPES), which allowed it to develop cutting-edge technical solutions to explore oil and gas in ultra-deep sea reserves. Petrobras has further stimulated innovation and dynamism through partnerships with local suppliers and service providers.

Another feature of the subsystem of production and innovation in Brazil is the relative importance of **SMEs** to Brazil's innovation efforts in the past decade. In line with recent industrial policy and the increasing prominence given to the role of technology and innovation for the competitiveness of Brazilian industry, specific programs for SMEs have been developed in recent years. Many of these initiatives have been included in recent policy programs and involve support for start-ups (especially subsidized interest rates, grants, technical support and training of human resources), venture capital, and technology parks and incubators. There is a continuous effort (by BNDES, for instance) to expand the participation of micro and small enterprises as beneficiaries of credit lines, incentives for innovation, training and export promotion. The Brazilian Innovation Survey (PINTEC) provides evidence on the impact of the above-mentioned policy initiatives on innovation in SMEs. Table 2 shows the most recent published data on the evolution of the aggregate innovation rates of enterprises by size.

Table 2: Firms in Brazil that have introduced innovations, by size, from 1998 to 2011, innovation rate (%)

Number of employees	1998–2000	2001–2003	2003–2005	2006–2008	2009–2011
Total	31.5	33.3	34.4	38.6	35.7
10–29	25.3	30.4	29.8	37.4	33.9
30–99	37.6	34.5	35.8	37.6	36.4
100–499	51.4	44.9	58.3	45.1	45.2
500 or more	75.6	72.6	79.6	71.7	56.0

Source: IBGE, Directorate of Research, Department of Industry, Technological Innovation Survey (PINTEC) 2011, 2008, 2005, 2003 and 2000.

As is the case in other countries, the data show a positive relation between the size of companies and their innovative performance. The most notable change, however, is the increase since 2003 in the percentage of innovators amongst firms that have up to 99 employees. In contrast the share of innovators amongst firms with 100 or more employees has declined. The data for the latest survey also show that most of these innovations relate to products and processes that are new only to the firm that introduced it, which involves lower costs and risks, rather than new to the industry.

4.2. Subsystem of education and research

The subsystem of capacity-building in science, technology, education and research is comprised of several elements: primary and secondary schooling, undergraduate education, graduate education, research institutes, and vocational education.

The Brazilian **school-age education** system consists of public and private primary and secondary schools. Most children and youths attend public schools, but private schools are qualitatively better than public ones. Access to school-age education of good quality is, therefore, limited, which promotes a vicious circle of social inequality. Those who are affluent enough to attend private schools have higher chances of entering a high-quality university and consequently a better chance of securing high-skill and highly-paid jobs.

The Brazilian **higher education** (undergraduate) system includes both public and private universities. The system includes different types of institutions: colleges (the majority of the institutions), universities, and technical training centers and institutes. In contrast to school-age education, *public* universities are, on average, better than private ones. Moreover, the country's higher education system is marked by elitism, with just 10 percent of the population aged between 18 and 24 going to university. There is also a concentration of higher education institutions (HEIs) in the Southeastern region of Brazil, which has 49 percent of all HEIs, with 18 percent in the Northeast, 16 percent in the South, 10 percent in the Center-West, and only 6 percent in the North (Dantas, 2007).

The establishment of the Prouni program in 2005 (see policy section below), which granted scholarships for students at private universities, led to a substantial expansion of the higher education system, which started to reach

the previously excluded population. Furthermore, new federal universities, technological institutes, and *campi* were created that started to change the regional distribution of the Brazilian higher education system. The latest higher education census (2011) showed a more even distribution of HEIs, particularly those that provide technical training.

Recent academic analyses of the Brazilian NSI has identified as one of its strengths its **graduate education** system, with more than 2000 master's programs and 600 doctorate programs. This is the result of a state policy that maintained its support to graduate programs and students over several decades through two agencies. The first is CNPq (the National Council for Scientific and Technological Development, affiliated to the Ministry of Science, Technology and Innovation), which was founded in 1951 and dedicated to the promotion of scientific and technological research. The other is CAPES (affiliated to the Ministry of Education), which is in charge of promoting high standards for post-graduate courses in Brazil.

However, a weakness of the Brazilian graduate education system is that the vast majority of PhDs (84.23 percent) end up being employed either in educational institutions or in public administration – not in the business sector, where they could directly contribute to the business R&D and innovation effort. Furthermore, the system exacerbates this, with CAPES ascribing greater weight to scientific publications when evaluating postgraduate programs than, for example, collaboration with non-academic institutions, other dissemination activities or the impact of scientific research on business strategy or public policy. On the other hand, a positive consequence of this system has been a significant increase in the number of publications by Brazilian scientists. In 1996, Brazil ranked 21st in the number of scientific publications, but increased to 13th place in 2014, higher than many OECD countries. Furthermore, the number of citations per document – which is a rough indicator of the quality and relevance of the publications – is on a par with the most productive countries.

The Brazilian system of **vocational education** and adult training is not fully developed and is insufficient to meet the demands of industry (Cassiolato, 2015). The system consists of both public and private institutions. A key obstacle to the former is the lack of resources, while private institutions are seen as elitist due to the high fees they charge. Overall, there is a mismatch between the kinds of training offered by these institutions and the demands of the productive sector, which may be due to the lack of a proactive attitude by business enterprises regarding training and capacity-building. This diagnosis led to the establishment, in 2011, of a governmental program called Pronatec to promote vocational and technical training (see policy section).

4.3. Subsystem of public and private funding

A key issue for the economic development of the Brazilian economy has been the supply of funding for long-term projects. Even though the domestic capital market has flourished in recent decades, the private financial sector has concentrated on supplying credit to household consumption and short-term credit to firms, for which it could charge high interest rates with relatively little risk.

The private banking system in Brazil tends to invest in government bonds, which offer high yields. This preference for high-return, low-risk investments is influenced by Brazilian monetary policy and in particular the high interest rate policies of the central bank (Kregel, 2011) With banks able to earn high returns on Government securities, they had no need to invest in high risk, high yield innovative projects. Lending to households and firms tended to be at relatively high interest rates on short-term loans. Consequently, 75 percent of the loan portfolio of the top private banks is still concentrated in loans of less than five years, whereas the corresponding figure for BNDES's portfolio is 54 percent. Moreover, the portfolio of national private financial institutions is highly concentrated in low-risk lending.

The private equity (PE) and venture capital (VC) market in Brazil is relatively small, but is growing fast (from USD 5.6 billion of committed funds in 2005 to USD 34 billion in 2009). However, it is devoted to 'fast-follow' firms and proven business models, rather than to high-risk innovative start-ups. Furthermore, the Brazilian capital market is not very friendly to small IPOs, which means that VCs tend to seek exits through merger and acquisition (M&A) deals. This means that the PE/VC market is not very liquid and is therefore not particularly attractive to private investors. Public funding institutions (namely, BNDES and FINEP) have, therefore, set up their own programs. One of the most important initiatives is the CRIATEC seed capital fund, which receives 80 percent of its resources from BNDES and the rest from a private partner. CRIATEC has mostly targeted start-ups in the ICT and biotechnology sectors (Cherobim *et al.*, 2011). Through equity investments by its subsidiary BNDESPar, the bank also invests in innovative SMEs (Mattos, 2008). Through these initiatives, BNDES fills a gap in the Brazilian system of innovation whilst also encouraging the development of a VC market in Brazil.

In summary, the Brazilian private financial sector currently plays a very small role in funding R&D and innovation projects, so that public policies for financial instruments are a key element in Brazil's innovation policies.

4.4. Subsystem of policies and regulations

In Brazil, as in other Latin American and developing countries, productive investments such as those in innovation and technical change are strongly influenced not only by specific industrial and STI policies (explicit policies), but also by macroeconomic policies (implicit policies) (Herrera, 1972). Macroeconomic variables such as inflation, public expenditures in general, and interest and exchange rates can all have a significant impact on productive investments; they may reinforce or hinder specific policies. In fact, in Brazil, some consider that implicit policies affect the development of its national innovation system more significantly than explicit policies (Coutinho, 2005; Erber, 2014).

Therefore, in this section we provide an analysis of both explicit and implicit policies. We also discuss in this section other complementary policies that influence the innovation system, positively or negatively, such as health, defense, social and environmental policies.

4.4.1. Explicit STI policies

After the Brazilian industrialization strategy based on import substitution reached its limits in the 1980s, industrial policy faded from the policy agenda. Policy efforts in this period focused primarily on controlling public debt and inflation. Indeed, the only explicit STI policy of the 1980s was the National Policy for Information and Communication Technology, which aimed to create a national ICT sector, mainly through protecting the domestic market for national producers.[11].

The trend away from explicit STI policies continued through the 1990s, when Brazil adopted macroeconomic policies based on the Washington Consensus, through restrictive monetary and fiscal policies, market and trade liberalization, privatization and the attraction of foreign direct investments (Belluzzo and Carneiro, 2003). Despite the relatively low priority to explicit industrial, trade and innovation policies, a plan was enacted in the 1990s (the Industrial and Foreign Trade Policy – PICE), seeking to modernize Brazilian industry mainly through exposure to international competition. The plan reduced or completely eliminated tariff and nontariff protection mechanisms (including subsidies to certain sectors, for instance). PICE also called for a set of horizontal policy measures to promote technological change and innovation, based on fiscal

[11] The Brazilian ICT strategy is regarded as a failure in terms of creation of a hardware industry, but achieved relative success in software and banking automation (although that success is also due to the need for banks to cope with huge inflation rates).

incentives (R&D tax breaks) and support for total quality and productivity programs at the firm level. However, this second group of policies was not fully implemented.

In 1999, explicit industrial and innovation policy began to rise up the policy agenda. New plans were elaborated following the guidelines of PICE for horizontal measures. “The difference was that the Federal Government started to recognize the need for intervention to correct so-called ‘market failures,’ particularly to establish partnerships between scientific and technological institutions and firms” (Cassiolato, 2015, p. 296). An early diagnosis was that the Brazilian subsystem of education and research (capacity building) was relatively strong, but science and technology institutions did not collaborate with firms to produce innovations due to the risks involved in the innovation process. Therefore, policies should encourage collaboration and foster long-lasting links between research institutions and firms. In fact, Brazil had been promoting such policies at least since the 1970s, with little success in creating the desired networks.

A second diagnosis was very much informed by a market failure perspective. To address problems of public goods, risk aversion and financial market imperfections, policies should be designed to (a) incentivize firms to innovate, (b) directly or indirectly promote technological infrastructure, and (c) provide financial support for start-ups and SMEs. To this end, the Ministry of Science and Technology set up the so-called ‘sectoral funds’ that aimed to restore the ministry’s own capacity to grant financial incentives for R&D and innovation, which had diminished in the 1980s and 1990s. The policy proposal also provided for tax incentives, reductions in the interest rates of public loans for R&D and innovation, and the establishment of non-reimbursable grants programs – none of which was fully implemented until 2003, except for tax incentives for ICT companies.

It was during the first administration of President Lula (2003–2006) that a real impetus towards explicit policies took place. In 2003, the federal government launched the Industry, Technology and Foreign Trade Policy (PITCE), an industrial policy plan, and the National Plan for Science, Technology and Innovation (PNCTI). In this period, two important laws providing for fiscal incentives and subvention (subsidies) for R&D and innovation were also enacted by the Brazilian congress. The first was the 2004 *Lei da Inovação* (Innovation Law), which, among other things, allowed for public procurement of (pre-competitive) R&D that aimed to develop a solution for a specific technical problem or an innovative product/process. The second law was the 2005 *Lei do*

Bem (Law of Good), which implemented the previous proposal of tax incentives for R&D.

Box 4: Plan Brasil Maior (PBM) and the National STI Strategy (ENCTI)

The main elements of the Plan Brasil Maior (PBM) included:

(a) incentives for investment and innovation: through tax relief (based on Lei do Bem), direct and indirect funds and a legal framework for innovation (based on the Innovation Law);

(b) foreign trade: introduction of tax reliefs, trade remedies, financing and guarantees for exports and trade promotion; and

(c) industry and domestic market defense, which involves the introduction of tax exemptions on payroll, a special automotive regime, government procurement, and harmonization of funding policies.

PBM also identified and prioritized six strategic sectors (ICT, pharmaceutics and health industry complex, oil and gas, defense industrial complex, aerospace, and renewables).

The National STI Strategy (ENCTI) defined quantitative targets for policies that aimed to improve the Brazilian innovation system. These were:

- Increase the GERD/GDP ratio from 1.16 in 2010 to 1.8 in 2014 (the same goal as PBM).
- Increase the BERD/GDP ratio from 0.56 in 2010 to 0.9 in 2014.
- Increase the share of industrial firms involved in innovation from 38.6 percent in 2010 to 48.6 percent in 2014.
- Increase the number of firms doing continuous R&D from 3425 in 2008 to 5000 in 2015 (excluding state-owned firms).
- Double the number of innovative firms making use of the Good Law from 6130 in 2009/2010 to 12260 in 2014.
- Increase the percentage of innovative firms that make use of at least one government innovation support measure from 22.3 percent in 2010 to 30 percent in 2014.

ENCTI also defined nine strategic sectors. In addition to the six identified in PBM, it included ST&I for social development, nuclear technologies, and biotechnology & nanotechnology. It also expanded the renewable energy focus of PBM to the promotion of the green economy (renewable energy, climate change, biodiversity, oceans and coastal zones).

Source: Authors' elaboration.

PITCE and PNCTI were replaced with new industrial and STI plans in 2007–2008, following President Lula's re-election: the Productive Development Policy (PDP), and the Action Plan for Science Technology and Innovation (PACTI). Lula's mandate was followed by the government of President Dilma (2011–2014), which also established two new strategic plans (detailed in Box 4

above): the *Plano Brasil Maior* (PBM – 'Greater Brazil Plan') and the National Science, Technology and Innovation Strategy (ENCTI).

The relative success of PAISS led to the establishment of 11 other *Inova* sub-programs modeled on the original (Box 5). In total, 12 ministries were involved with various *Inova* programs. The demand for resources was almost three times greater than the available resources, which highlighted business interest in this type of direct and systemic innovation policy.

Box 5: Inova programs

In 2012, the federal government announced Inova Petro (for the oil and gas sector) and Inova Energia (energy sector). In 2013 it established Inova Saúde (health sector), with actions devoted to pharmaceuticals and to medical equipment, Inova Defesa (defense sector), PNI (the National Program for Incubators and Technology Parks – see below), Inova Agro (agriculture), and Inova Sustentabilidade (for sustainability projects). In 2014 it set up Inova Telecom (telecommunication sector), Inova Petro 2, and PAISS 2.

PNI - Technology parks and incubators

In Brazil, public initiatives in support of technology parks date back to the 1980s, but it is in the 2000s that FINEP and CNPq substantially increased their investments in technology parks. PNI was established in 2009 and was later (2013) included in the Inova program. As of June 2013, Brazil had 94 known technology park initiatives, 28 of which were in full operation, hosting 939 enterprises that employed 32,237 persons (including1,098 PhDs and 2,950 masters). Regarding incubators, a study published in 2012 identified 384 incubators in Brazil, supporting 2,640 start-ups (Anprotec/MCTI, 2012). In 2013, the Brazilian Ministry of Science, Technology and Innovation established a project that sought to evaluate the impacts of PNI, to compare the operations of Brazilian technology parks with those of international peers, and to suggest improvements to public policies in support of technology parks and incubators.

Source: Authors' elaboration.

The *Inova* model can be characterized by the following aspects (cf. De Negri, 2015, p. 365–366; Nyko *et al*., 2013).

1. It targets technological challenges in specific fields, sectors, or themes that have strategic importance for Brazil or offer market potential.
2. It integrates public policy instruments, particularly funding tools (grants, subventions, subsidized credit, and equity) and public procurement.

3. It establishes partnerships between FINEP and BNDES, with ministries, other public agencies, and/or SOEs.
4. It fosters networks of innovation, promoting partnerships between research institutions and firms, based on business (innovation) plans and not specific projects.

Business innovation plans are selected through a competitive call for applications to ensure excellence of funded projects.

Although this model, which arose from PAISS, was largely emulated by the other sub-programs, some of the initiatives had a much broader technological focus (such as the energy program, which had one of its focuses on renewable energy in general rather than specific types of renewables or technological components) or did not define a sectoral focus at all (such as the sustainability program). Nevertheless all these programs had in common the identification of a mission. Unlike the Brazilian tradition of supply–push innovation policies, *Inova* is a truly systemic policy initiative. Given its characteristics of directing financial resources and establishing sectoral networks (with public, private and scientific institutions) to help develop technologies that address specific challenges, the *Inova* program can be seen as an example of mission-oriented innovation policy.

In 2014, President Dilma enacted another explicit policy program: the National Program of Knowledge Platforms (PNPC), which sought to develop the Brazilian system of innovation in three areas: energy, agriculture, and health. It also sought to exploit the potential of the Amazon and its biodiversity in order to promote Brazil to the status of environmental leader. The PNPC's institutional arrangement connects leading researchers in the field with a managing institution and firms, plus suppliers (De Negri, 2015). Research developed by the PNPCs targets the so-called 'valley of death'; that is, the stages of the innovation process between basic research and market development with highest technological risks and therefore the most difficulty obtaining financial resources. Whilst they are characterized as systemic, the PNPCs still have a supply–push bias, as the focus is on the scientific and research subsystem of the Brazilian system of innovation (Cassiolato *et al.*, 2015). It is still too soon to evaluate the impact of the PNPCs, which require continuity of resources in order to be successful and may therefore be impaired by the austerity agenda. To date, however, pure science–push policies (like the early establishment of technological parks) have had little impact in terms of diversifying the productive structure and increasing the propensity of firms to innovate.

4.4.2. Implicit policies: the macroeconomic tripod

In Brazil, macroeconomic policies are based on a so-called tripod, the three 'legs' of which are: inflation targeting by managing interest rates, pursuit of primary surpluses, and floating exchange rates. Established in 1999, the tripod was designed to guarantee price stability (or low inflation rates), to stabilize or even reduce the public debt/GDP ratio, and to free monetary policy from the need to promote balance of payment adjustments (Oreiro, 2015). Proponents of an attractive environment for productive investment argued that, in the long run, this arrangement would lead to a level playing field where investors would feel confident to invest in the real economy.

Nassif (2015) argues, however, that the macroeconomic regime has been incapable of promoting price stability and, more importantly, economic growth. Rather than promoting private investment (which it failed to do), the tripod tended to hurt domestic enterprise and industry. The Brazilian macroeconomic disequilibrium of high interest rates and over-valued exchange rates resulted in an investment rate of just 18 per cent of GDP in recent years, which is compatible with only a very low growth rate of the economy (de Lacerda and Loures, 2015).

The high interest rates that were set in an attempt to keep inflation low (and reach the inflation target) created an incentive for the financial sector and even the business sector to invest in government bonds, rather than in riskier productive assets, infrastructure or innovation (Kregel, 2009). The Brazilian exchange rate anchor was officially abandoned in 1999 in favor of a floating rate (Frenkel and Rapetti, 2010). In practice, however, the Brazilian government kept its policy of supporting the *real* indirectly by selling high-yield treasury bonds rather than directly by selling dollars. As a result, many firms sought to hedge against further appreciation of the *real* by investing in derivatives, and thus reported heavy losses when the global financial crisis of 2007-8 broke (Kregel, 2009). The monetary and exchange rate policy thus tended to favor importers, to the detriment of Brazilian industry and exporters, ultimately contributing to the deindustrialization process not only via the appreciation of the exchange rate but, more importantly, through a low level of productive investments (da Silva, 2014; de Lacerda and Loures, 2015; Serrano and Summa, 2015).

Although a more expensive *real* has helped entrepreneurs invest in imported capital goods, the technological dependency of Brazilian industry was reinforced. Since 2011, the trend of an overvalued exchange rate has been

reversed but, amidst an economic recession, its impact on business investment in productive assets and innovation remains to be seen.

Finally, the pursuit of primary surpluses by the central government also tends to have an adverse effect on domestic investment, as it constrains the Brazilian federal government's capacity to invest. Jorge and Martins (2013) argue that fiscal contraction promoted in 2010–2011, in an attempt to reach the primary surplus target, negatively impacted on aggregate demand and decisively contributed to the slowdown of Brazilian economy. They further argue that the volatility of Brazilian economic growth in the 2000s was associated with restrictive fiscal policy targeting a primary surplus. The implementation of austerity policies in 2015, cutting public spending and investment in every area of the executive government, may make matters worse.

In summary, Brazil's macroeconomic policy framework of inflation targeting, exchange rate fluctuation, primary surpluses, and expenditure cuts (austerity policies) has tended to impair the effectiveness of explicit industrial and innovation policies. This does not mean that innovation policy attempts will necessarily be in vain, but it does mean that public resources for R&D and innovation and innovation policy instruments need to be used strategically.

4.4.3. Complementary policies: Health

The provision of health care services is a state duty guaranteed by the Brazilian constitution of 1988. To achieve this, Brazil's *Sistema Único de Saúde* (SUS, akin to UK's National Health System) was created through specific legislation in 1990. In 2011, Brazil was the sixth-largest pharmaceutical market in the world, with sales of more than USD 30 billion, and annual growth of 14.3 percent between 2003 and 2011 (Palmeira Filho *et al.*, 2012). The Brazilian Ministry of Health spends approximately USD 7 billion per year on drugs and health products, the majority of which goes on imported products (Sorte Junior, 2012). With exports much smaller (USD 1.45 billion in 2011), the pharmaceutical sector contributes to a significant trade deficit.

The health sector has been the focus of public policies since the 1990s, creating opportunities for STI initiatives. Overall, the industrial policies for the health sector established in the last 15 years have aimed to revamp the sector, strengthening national pharmaceutical firms, and granting universal access to medication and health care, while also enabling the country to produce biological drugs (particularly existing ones with patents that are due to expire), thereby creating a biotech industry (Gomes, 2014). Brazil's health policy is distinctive for its ambition of developing not only drugs, but also medical

equipment, diagnostic systems, and other technologies. One of the initial impulses came in 1999–2000 with the enactment of legislation that led to the creation and expansion of a market segment for generic drugs.[12] This segment grew from 6.4 percent of the market in 2003 to more than 20 percent in 2011. In 2003, the PITCE industrial policy plan selected the pharmaceutical industry as a strategic sector. In 2007, the federal government established the PACTI, which, among other things, included initiatives to promote the development of the pharmaceutical sector, such as R&D and innovation funding in strategic areas such as biotechnology.

In the same year, the *Programa Mais Saúde* (a strategic program for the health sector, also known as *PAC Saúde*), aimed to strengthen the Health Economic-Industrial Complex in order to meet the goal of universal access to the SUS, by transforming the Brazilian productive and innovative structure (Paranhos, 2010). The 2008 industrial policy plan *PDP* also included the pharmaceutical industry as a strategic sector, together with biotechnology; the focus was on the generation of scientific and technological knowledge to address the vulnerabilities of the national health system. Unlike the previous plan (PITCE), the PDP established quantitative targets; in the case of the health/pharmaceutical industry, this included a reduction of the trade deficit and the production of 20 strategic drugs (Paranhos, 2010; Metten *et al.*, 2015).

In the wake of these strategic plans, the Ministry of Health enacted two federal executive orders defining strategic products (drugs, inputs, and equipment for the health sector) that should be the focus of public policy for their national development. The executive order stated that BNDES was to support the national development and production of these strategic products, leading to a new program for the pharmaceutical industry *Profarma* (see Box 6). Besides BNDES resources, funding for the health sector comes from specific sectoral funds and other resources managed by FINEP.

Box 6: BNDES' *Profarma* program

In April 2004 BNDES launched the *Profarma* program, which "represented a response…. to the demand for specific credit lines that could contribute to the growth of the domestic pharmaceutical industry" (Palmeira Filho *et al.*, 2012, p. 70).

The program was structured around three sub-lines of funding: *Production*,

[12] Prior to this, two important legal developments affected the health sector. The first was the Law of Industrial (Intellectual) Property (Law 9,279 of 1996), which was motivated by Brazil's ratification of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. The second was the creation of the *Agencia Nacional de Vigilância Sanitária* (Brazil's equivalent of the US Food and Drug Administration), which, among other things, regulates the price of drugs in Brazil, establishes best practices for the pharmaceutical industry, and approves sales of new drugs.

Restructuring, and *Innovation* (previously called RD&I). The first two sub-lines aimed to strengthen the Brazilian pharmaceutical sector, which almost disappeared in the early 1990s when it was suddenly opened up to international competition, with companies going bankrupt or being acquired by foreign competitors (Filho et al., 2012).
Since 2004, Profarma has gone through two 'stages' (2004–2007 and 2007–2012), and it is currently in its third stage (2013-2017)). This third stage expanded its scope to include a new sub-program, Profarma Biotechnology.
Overall, the program seems to have successfully promoted a culture of innovation within Brazilian pharmaceutical companies and developed new drugs for the Brazilian market (Pieroni *et al.*, 2011; Palmeira Filho *et al.*, 2012). In April 2013, BNDES also announced the creation of a new program of funding of medical equipment (*Inova Saúde – Equipamento Médico*). This joint program with FINEP aims to fund the development of medical equipment and diagnostic processes.

Source: Authors' elaboration.

The latest plan – *Plano Brasil Maior* – emphasized *public procurement* as a demand-side tool for fostering the competitiveness of sectors for which government demand is significant, such as health (Gadelha *et al.*, 2012). To this end, the laws governing procurement were reformed to allow the strategic use of the state's purchasing power to promote national development.[13] This legislation complements the Innovation Law, which allows the government to procure (pre-competitive) R&D that addresses specific technical problems.

Another public procurement strategy, which began with the PDP (in 2009), is the establishment of public–private partnerships in the health sector. Productive development partnerships, as they are known, involve a national laboratory, a foreign laboratory, and a national supplier of pharmacological or biotechnological inputs. Up to 2013, more than a hundred productive development partnerships were formed to develop various chemically synthesized and biological medicinal products, as well as numerous devices such as stents, intra-uterine devices (IUDs), defibrillators, and pacemakers (Gomes, 2014).

In summary, Brazil's health strategy is a well-developed state-led policy that has been able to mobilize a range of public and private actors to develop science- and technology-based innovations. Unlike other sectors, the health sector has

[13] The amendments allowed for preference margins for national content in public tenders (which could cost up to 25 percent more than an imported product or service). The tendering process should also consider job creation, income impact, and tax revenues as criteria for selection of suppliers, not just the lowest price.

been able to foster partnerships between different types of public agencies, businesses, and research institutions/universities. It can therefore be seen as a systemic mission-oriented policy.

4.4.4. Complementary policies: Defense

The Brazilian defense industry was profoundly affected by the liberalization policies of the 1990s, which led to a progressive decline of the Brazilian defense industrial base, with the accompanying loss of external markets and stagnation of the internal market. The creation of the Defense Ministry in 1999 provided a new opportunity for the establishment of an industrial strategy for the defense sector, although this opportunity was not initially accompanied by concrete budgetary, fiscal and funding policies.

In 2008 the Brazilian government issued the National Strategy of Defense (*Estratégia Nacional de Defesa* – END), which aimed to rebuild the Brazilian defense industry, to enable Brazilian military forces to provide security for a country of continental dimensions, with particular attention to the defense of Brazil's natural resources (such as the newly discovered pre-salt oil and gas reserves). One of the aims of the END is to reorganize the national defense industry, which overlaps with the sphere of innovation policy.

The national defense strategy is centered around state-owned military companies that should work at the technological frontier, without a focus on profit maximization and taking a long-term approach to technological development, in partnership with suppliers. The strategy envisages systemic partnerships between private and state-owned companies, universities, and research centers in three strategic sectors to be fostered by defense-related science, technology, and innovation initiatives: aerospace, cybernetics, and nuclear energy. All of these sectors create opportunities for the development of dual-use technologies that could help address military and civil challenges. The strategy also lists specific technologies to be developed and controlled by the national industry, such as jet fighters, smart weaponry, submarines (both nuclear and conventional), drones, and communication technologies.

To address the challenge of developing these technologies, the END proposes both regulatory and fiscal measures, and the use of public procurement. Despite this, use of public procurement of defense technologies and products to promote innovation is rare, due to the difficulties imposed by existing

procurement legislation. There are special procedures[14] for buying, contracting, and developing defense products and systems and preferential conditions for domestic firms. However, the legal procedures are complicated and restrictive and do not allow for a systemic perspective on the relative roles of the state, business, and academia in the process of developing defense technologies and innovations. In this sense, acquiring 'from the market' has been the preferred route for defense products, to the detriment of an innovation-based approach to public procurement (Brustolin, 2014).

A study by ABDI (2011) analyzed the situation of the Brazilian defense industrial base and diagnosed the need for public policies to promote domestic technological development, increase the scale of the domestic industry, and strengthen the linkages in the domestic production chain. ABDI listed 14 policy proposals that were mainly supply-side instruments, with the exception of the recommendation that public procurement give preference to the national industry. Brustolin (2014) addressed the public procurement policy gap. Using the US as a benchmark, and considering the Brazilian historical context and the current objectives of the END, Brustolin proposed a new integrated model for the *state-led development and acquisition* of dual-use technologies, through government-industry-university cooperation.

In 2013, through the *Inova Defesa*, the Brazilian END started to be translated into a concrete mission-oriented program, designed by FINEP and BNDES in coordination with the Defense Ministry. Despite initial interest from the Brazilian defense industry, the program has only achieved partial results, due to the lack of a firm commitment by the state to acquire the technologies and products that would be developed. In this sense, while the National Defense Strategy represents an enabling legislation for the establishment of mission-oriented programs, the effectiveness of these programs requires the fine-tuning of public policy mechanisms and instruments to the current industrial and technological challenges of the Brazilian defense sector.

4.4.5. Complementary policies: Socio-economic inclusion and education

Brazilian innovation policy has not traditionally put social inclusion center stage. However, there is a growing effort to address social issues, especially in areas where innovation policy overlaps with other policies. Technological diffusion and the development of technologies adapted to the needs of economically

[14] Law 12,598, enacted in 2012, created an exception to Law 8,666, dating from 1993, which established strict control mechanisms for the use of the state's purchasing power.

disadvantaged people have been very relevant in the context of local productive arrangement policies (APLs) and regional development policies. The development of new technologies for infrastructure and housing connect to the program for expanding popular housing (*Minha casa, Minha vida* – 'My home, my life').

The industrial policy plans implemented since 2003 give a more prominent role to the reduction of regional and local inequalities in the country. This led to the creation in 2004 of a specific institutional set-up that focused on APLs. The *Permanent Working Group for Local Productive Arrangements* (GTP-APL) is part of the organizational structure of the Ministry of Development, Industry, and Foreign Trade, but consists of a forum for the convergence and articulation of many public and private organizations.

The main focus of the GTP-APL is to set a common methodological framework and avoid duplication of initiatives aimed at APLs, promoting interaction and communication between the institutions involved. The GTP-APL also promoted the creation of APL support centers at the level of each state, which were located within the state secretariats for industry and development of each state. Similar to the GTP-APL itself, these state organizations include representatives from many different public and private organizations. In some states, these centers were established only to benefit from potential funds coming from the federal sphere; in other states there is a dense network of institutions, with structured initiatives involving a large number of APLs (Matos *et al.*, 2012).

In most cases, those productive structures that have been left out of major structural and sectoral programs are targeted through the APLs policy. Often these are traditional sectors activities, which tend to be more dispersed throughout the national territory, including less dynamic regions. This underlines the complementary and often compensatory character of the APLs policy. It also constitutes an interesting starting point for promoting the decentralization of production. A main heading of the national development program is 'regionalization'. In this context, APLs are a channel for the mobilization of local and regional potential and for promoting productive activities associated with major infrastructure projects.

There is great potential in linking these APL initiatives with policies to promote entrepreneurship and micro-credit. The inclusion of social classes with lower income and the focus on the domestic market has yielded very positive outcomes in recent years. A major part of the policy plan for reducing poverty is based on APL initiatives on two related fronts: provision of essential public services and inclusive production (BNDES, 2011). Perhaps the most relevant

example of a 'social-inclusion policy' involves the case of health policies, as discussed in section 4.3.2.2.

Education programs are a third type of policy, complementary to explicit STI policies, that promote socio-economic inclusion (see Box 7).

Box 7: Education policies: Prouni, Pronatec, and Science without Borders

Three education programs implemented since 2005 have sought to fill a gap in the Brazilian system of innovation, which is the provision of skilled workers.

Created in 2005 (through Law 11,096), *Prouni* – also known as 'University for Everyone' – is an education program that seeks to promote the inclusion of youths from lower socio-economic conditions (family income of up to three times the minimum wage), who are usually enrolled in the public school system, to the university system. Prouni grants full-time scholarships so that students can enroll in private universities. Since its creation, almost 1.5 million scholarships have been granted to undergraduate students.

In 2011, the Brazilian Federal government established *Pronatec*, the National Access Program to Technical Education and Employment (through Law 11,513). The program aimed to expand and promote the regional inclusion of vocational and technical education courses. Pronatec is a complement to the cash-transfer program *Bolsa Família*, whose beneficiaries are *Pronatec*'s target population. Courses are funded by the federal government and offered free of charge by federal, state level, and local institutions (see Annex I for a description of this system). Since its creation, *Pronatec* has registered more than eight million enrolments in vocational courses.

Science without Borders is a joint program of the Ministry of Education and MCTI that was created in 2011 to promote the internationalization of Brazilian academic researchers. It grants many types of scholarships for Brazilian students to obtain degrees (partial or full) in international academic institutions of excellence. The program also grants scholarships to foreign researchers moving to or seeking partnerships with a Brazilian academic institution. The research areas covered by *Science without Borders* are limited to the STEM field (science, technology, engineering, and mathematics) and life sciences. The program aims to grant more than 100,000 scholarships per year.

Source: Authors' elaboration based on http://pronatec.mec.gov.br/institucional-90037/o-que-e-o-pronatec; http://prouniportal.mec.gov.br/o-programa;and http://www.cienciasemfronteiras.gov.br/web/csf/o-programa (accessed on 27/11/2015).

The government in 2003 established new housing, education, and health programs to improve living standards and access to basic services. On top of

these measures, the industrial policy plans aimed to increase employment, the skill level of the workforce, and overall living standards. For instance, one mission of the 2008 PDP was to extend access to basic goods and fundamental services in order to improve living standards. The latest plan (PBM) set an explicit goal of improving the skills of industry workers (to increase the proportion of workers who had completed high school from 53.7 percent in 2010 to 65 percent in 2014). It also set the goal of increasing access to broadband Internet (from 13.8 million to 40 million households by 2014).

Other initiatives to promote socio-economic policies include the cash-transfer program *Bolsa Família* and the appreciation of the minimum wage in real terms. Although outside the scope of this study, one result of the cash transfer and minimum wage policies was the inclusion of vast portions of the Brazilian population in the mass of consumers. Thus, the potential market for consumer goods increased greatly. Furthermore, the policy created scope for what is referred to in the innovation literature as "frugal innovation"; that is, innovative yet affordable products that meet the needs of resource-constrained consumers (Zeschky *et al.*, 2011).

4.4.6. Complementary policies: Climate, environment, and energy

While climate change is a global issue, environmental policies in general are of particular relevance to Brazil, which holds 12 percent of the world's freshwater reserves and 30 percent of its remaining tropical forests (70 percent of the country is still covered with native vegetation). Brazil is one of the most biologically diverse countries in the world, with seven distinctive terrestrial biomes that are rich in biodiversity (plus the Brazilian marine biome). Therefore, any attempt to address global environmental challenges, and climate change in particular, will require Brazil to play a leading role. This challenge is also an opportunity for Brazil. The strategic exploitation of biomes and natural resources could be used as a springboard for smart (innovation-led), inclusive,[15] and sustainable development.

Brazil has played a critical role in international negotiations on tackling climate change. The cornerstone of Brazil's climate change mitigation policy, with ramifications for the country's environmental policy, is the National Policy on Climate Change (NPCC), established in 2009. The NPCC sets a voluntary

[15] Three of the richest biomes in terms of biodiversity – the Amazon, the *Cerrado* (a type of savannah), and the Caatinga (thorny scrub) – cover the least developed regions of Brazil (the Northern, the Northeast, and the Center-Western regions). Developing sustainable bio-based innovations, from new drugs and cosmetics to new materials and renewable energy inputs, could allow the inclusion of vast portions of the Brazilian population into the socio-economic system.

commitment to adopt mitigation actions in order to reduce, by 2020, emissions of greenhouse gases (GHG) by 36.1–38.9 percent (against a 2005 baseline). The NPCC also includes targets to reduce deforestation and increase ethanol use, reforestation, recycling of urban garbage, energy efficiency, and the generation of electricity from renewable sources.

The public instruments used to achieve the voluntary targets include fiscal and tax measures, as well as specific credit funding lines provided by funding agencies like BNDES and FINEP. Brazilian public funding agencies and banks have had a strong incentive to establish new programs to help the country meet the NPCC's targets. Furthermore, any funding program for specific industrial sectors established since 2010 is required to consider climate change mitigating mechanisms. In 2012, BNDES announced the creation of a new climate fund to finance projects to reduce greenhouse gas emissions. In 2013, BNDES and Finep announced the *Inova Sustentabilidade* program, which, among other things, targeted technologies for sustainable production (for example, higher energy efficiency and lower emissions).

Brazil also submitted its contribution to the 21st annual Conference of Parties (COP21) in Paris in December 2015, which reached a new global agreement to reduce the emissions that cause climate change. The Brazilian contribution includes the goals of reducing emissions of greenhouse gases by 37 percent by 2025 and by 43 percent by 2035 (compared to 2005). In addition, Brazil committed specific actions to mitigate deforestation and special energy policies to increase the share of renewables in the energy matrix. Both types of commitments create opportunities for the Brazilian national system of innovation. Mitigating deforestation, for example, will require actions such as the development of monitoring technologies and alternative materials to wood, while increasing the share of renewables in the energy matrix will provide space for developing an indigenous renewable energy industry.

Brazil has a track record of actively supporting the use of energy from renewable sources. The best-known initiative was the development and use of ethanol as an alternative to gasoline; the *Proálcool* (Proethanol) program was triggered by the energy shocks of the 1970s. Ultimately, this initiative led to the flex fuel automobile power train, an innovation developed by the Bosch subsidiary in Brazil, first adopted by Volkswagen-Brazil in 2003, and quickly followed by other automobile companies producing in the Brazilian market (Teich, 2006). The biomass for the production of ethanol – sugarcane – is very competitive in global terms and does not affect food crop production like corn, which is used in the USA.

Brazil is known for having one of the cleanest electricity generation matrixes in the world, with more than 80 percent coming from hydroelectric plants (Juárez *et al.*, 2014). Since 2004, Brazil has actively promoted the generation of electricity from alternative renewable energy sources in order to compensate for the seasonal fluctuations in hydroelectricity production (Cunha *et al.*, 2012). The first program was *Proinfa*, which sought to support the generation of electricity from sugarcane biomass, small hydro plants, and wind sources, through a standard feed-in tariff model, and with requirements that new plants use nationally manufactured equipment. However, the most successful program in support of a renewable energy source for electricity – namely, wind power – was based on a demand-side tool: an innovative energy auctioning model, which made wind energy competitive with mainstream energy sources within a few years of being first implemented in 2008 (Cunha *et al.*, 2012; Juarez *et al.*, 2014). The auctioning model is being considered for the promotion of other renewable energy sources like solar. One caveat on the overall strategy is that Brazil does not have a large production-base of wind and solar power generation equipment, nor a network of services for this industry. Thus, in order for the energy to contribute to the development of the country, it will require complementary science, technology, and innovation policies.

In this sense, the NPCC and associated environmental and energy policies are an enabling legislation for the establishment of mission-oriented innovation programs that seek to address environmental and climate challenges.

5. Interviews: findings and analysis

We broadly follow the interview structure (see Annex III) to analyze the main findings from the interviews carried out with representatives from the public sector, businesses, and research institutions (academia).

The first part of the interviews asked about the key strengths and weaknesses of the Brazilian system of innovation. The second part enquired about the quality of relationships between private, public and academic institutions and the third part focused on the effectiveness of public policies and policy instruments. The fourth part asked about (a) the distributions of risks and rewards in the Brazilian system of innovation, (b) possible challenges and missions that the Brazilian system of innovation could help to address, and (c) the relationship between innovation and socio-economic inequality. [16] To summarize the key points and issues raised by the interviewees, we present word clouds depicting the most recurring themes (the top 20 words mentioned in interviewees' answers). The statements and arguments presented in what follows come from the ideas and insights offered by the interviewees.

5.1. The Brazilian system of innovation: strengths and weaknesses

5.1.1. Perceived strengths[17]

There was a consensus amongst the interviewees regarding the core strength of the Brazilian system of innovation; that is, the achievements of the subsystem of science and education. The word cloud in Figure 4 displays several words that are related to this subsystem, such as science, education, brains, academic, and research. The perception is that Brazil has developed a good infrastructure of science and education, and has acquired competences in areas where it is producing frontier research, such as health (led by Fiocruz and other research centers, including universities), agriculture/food (led by Embrapa), and energy (led by Petrobras' research center CENPES, and in the field of ethanol production). This is reflected in the growth in the number of publications, PhDs, and other scientific indicators. Whilst Brazil is not yet a "scientific power", as one of the interviewees put it, it has all the key elements of a well-developed science and education subsystem.

[16] The final part of the interview process was open-ended, which enabled interviewees to raise questions and to make suggestions. Those who took the opportunity to talk freely mainly praised the initiative and asked to have access to the final report of this study.
[17] In this section, we also report the answers to the question about the recent evolution of the Brazilian NSI (see Annex III), which all interviewees recognized as being positive.

Figure 4: Strengths of the Brazilian system of innovation – top 20 words

Source: Authors' construction.

Apart from the public research institutions mentioned above, other perceived 'islands of excellence' in innovation are represented by Embraer and the aeronautics research centers (aviation) and by the banking sector, which has core competences in automation. Whilst these competences do not always translate into frontier research,[18] they are seen as sources of advantage that could be used as levers for innovation. Brazil also possesses other natural advantages (mentioned by some interviewees, but not shown in the word cloud). These include Brazil's status as one of the most appropriate locations for launching of satellites (AEB's Alcântara launch center, which is the closest launching base to the Equator); the country's vast biomes and biodiversity; the abundance of natural resources, including those appropriate for the production of renewable energy (biomass, sunlight, wind); and the fertility of the soil for different crops (partly as a result of Embrapa's research efforts).

Another theme mentioned by interviewees is the existence of a public (state) apparatus in support of science, technology, and innovation, which has evolved positively over the past decade with the enactment of laws such as *Lei do Bem* and *Lei da Inovação*, and institutions such as BNDES, FINEP, CNPq, and other federal and state-level funding agencies. One interviewee from a public institution argued that "Brazil *is* capable of mobilizing significant resources for ST&I, despite the current austerity policy. We are a rich country; we are not

[18] Indeed, one consulted expert in the Brazilian system of innovation believes that banking automation is an area where Brazil has stagnated and is in decline.

Africa, Argentina or Greece!" Whilst Brazil "is not in a desert, for it has a strong developmental institutional infrastructure to support ST&I" (according to a first-tier representative of MDIC), the system is now "at a crossroads: it may progress or regress" as a consequence of the austerity agenda. Positively perceived public policies for innovation, such as BNDES's and FINEP's *Inova* programs and BNDES's seed capital program CRIATEC, should be continued and improved in spite of austerity measures.

A third theme that was identified as a strength of the Brazilian system of innovation is the existence of a strong domestic market for mass consumption, together with a public market for social provision, as a result of the state's constitutional duty to provide health and education (including science and technology) for the entire population.

Finally, some interviewees mentioned that a positive feature of the system is the young active workforce and the entrepreneurial spirit of the population. An interviewee from a foreign corporation said, "This is a very entrepreneurial country! Perhaps not as 'innovative' [technologically]; but individuals are prone to risk-taking."

The key strengths of the Brazilian system of innovation may be summarized by the following quote from a private VC manager: "Brazil has the brains, the money, and the infrastructure" to develop radical innovations. What seems to be lacking, as we will see next, is a coherent, visionary and long-term public policy agenda.

5.1.2. Perceived weaknesses[19]

Interviewees also displayed a relative consensus regarding the main weaknesses of the Brazilian system of innovation. First and foremost was the lack of a long-term agenda for innovation that provides a sense of mission to the system (see Figure 5).

One interviewee from a public agency noted that even when the state tried to establish long-term innovation agendas, the content was often "imported" from abroad, under the influence of think tanks or related to technological fads and hypes. This interviewee argued that, in any case, "there's a huge gap between the abstract visions and ambitions and the actual content of public policies for innovation." This opinion was shared by other interviewees. Furthermore, in the

[19] In this section, we also report the answers to questions (a) about a supposed gap between science/academia/research and business/production/innovation; and (b) about the missing aspects of the system.

absence of a long-term innovation agenda, there is often discontinuity in policies and projects. This frustrates business planning for the long term and is detrimental to the innovation process, which is cumulative, with long lead times. The discontinuity also makes evaluation difficult and prevents the public sector from learning and adapting policies.

Figure 5: Weaknesses of the Brazilian system of innovation – top 20 words

Source: Authors' construction.

The lack of long-term vision has resulted in a fragmentation of the innovation agenda amongst public institutions (including duplicated functions in various ministries, unclear competences of agencies, a lack of synergies), leading to the non-strategic use of available resources. Interviewees noted that a source of this incoherence is the increasing socio-economic demands on the Brazilian system of innovation, which often creates 'fiefdoms' and leads to pork barrel politics. One consequence is that businesses (and research institutions) often "shoot in all directions" to obtain support, (for instance, agents often apply for resources for the same project from BNDES, FINEP, and CNPq). There is also a perception that the public policy process is sluggish, and/or subject to the timing of the budgetary process, and that both are at odds with the timing of the innovation process.

Bureaucracy and regulation are a third source of weakness in Brazil's NSI, with two main consequences. "Bureaucratic vicious circles", as one fund manager called them, make it difficult for small businesses to thrive and are detrimental to entrepreneurship: "For the large company, these are costs, for the small they

are a matter of life and death." These "vicious circles" also lead to a risk-averse public sector, because bureaucratic controls exert negative pressure on the very institutions that should be taking on some of the risks of innovation, such as BNDES, FINEP, and even state-owned enterprises that are subject to the same controls. A first-tier representative of BNDES claimed that "procedural limitations" force the bank to adapt to the rules, and while it has been accused of committing "Type One errors" (businesses and projects that BNDES support, but supposedly should not), "I suspect BNDES commits a lot of Type Two errors – [risky] things we should support and do not support", due to a fear of being condemned for failure by control institutions.

A fourth weakness of the Brazilian system of innovation seems to be the flip side of one of its strengths. Specifically, the preponderance of academic and scientific institutions leads to a very high degree of autonomy of the research subsystem, independent of societal demands. There is a perception that this subsystem is self-oriented, partly the result of the institutionalization of an academic evaluation process (led by CAPES) that is biased towards strictly academic indicators such as publications or the number of doctors working in the scientific institutions.[20] As one high-level employee in MDIC put it: "Our scientific system is not mission-oriented. It needs to achieve a balance between blue sky and mission-oriented (basic and applied) research. Our science and technology system needs to be more committed [to societal demands]. We don't have the right of having an uncommitted science!"

The high degree of autonomy of academic and scientific institutions also results in a polarization between these institutions and businesses. Although Brazil has all the key elements of a developed system of innovation, "[t]he system is not yet integrated. [It's] Not a proper system: [it's] a constellation of subsystems. The system does not close the loop from S&T to innovation" (interview with a former secretary of MCTI and current BNDES representative). While an increasing number of post-graduates are being produced by Brazilian universities, businesses complain that those not absorbed by universities themselves are either not of the right kind (mainly engineering and hard science), or lack entrepreneurial and managerial competences. As one representative of the private sector claimed, Brazilian academia does not attribute the same importance to creating value to society through market innovations (versus knowledge creation) as cultures like America do.

[20] The requirement of "exclusive dedication" of university professors – that is, that professors work solely in the university, but not for own or third-party companies – has repeatedly being cited as one of the sources of the self-orientation of the science sub-system. The "exclusive dedication" law dates back to the 1960s; its reform is under discussion in congress, of which CNI/MEI is an advocate.

However, the gap between the science and education subsystem and the business/innovation (or production) subsystem is not the sole responsibility of the former, in the perception of interviewees (including those from business). The strategy of Brazilian firms is also one of the causes of the gap: most firms are short-termist and do not invest enough in innovation. "Our businesses lack 'animal spirit'", as one senior bureaucrat at MDIC claimed. Interviewees argued that the prevalence of a short-term strategy agenda was due to the following issues:

- Macroeconomic policy (particularly the cost of capital and over-valued exchange rates of the past decade).
- Discontinuity/lack of predictability in policies and the institutional framework; sluggish bureaucratic processes (including those connected to the protection of IP rights and to the import of technologies/machinery and inputs for research and innovation).
- Lack of exposure of domestic firms to world-class competitors.
- Reliance of national firms on an imitative strategy, in contrast to leading foreign-owned firms who operate in the most innovative and high-tech sectors and invest in R&D and innovation or import equipment and knowledge.

A high-level bureaucrat at MCTI summed up this issue with the Brazilian business sector: "Waking up the animal spirit … that's what's missing. We don't have an economic ecosystem where the 'animals' feel comfortable [risking and innovating]." Another public sector interviewee raised the following key question: "Under what conditions can a follower trajectory evolve into an innovation trajectory" and create demands and challenges for the scientific subsystem?

It is important to note that interviewees from all sectors recognized mutual prejudice that needs to be overcome. They also recognized some positive developments in business-academia relationships (also due to the development of technology parks and the work of BNDES, FINEP, Embrapii, CNI and the 'S' system). Such partnerships seem to be working in areas such as energy (oil and gas and electricity), health, agriculture, and aviation – precisely the sectors that are perceived as islands of excellence in Brazil. In the next section, we turn to the relationships between the state, businesses, and academia.

5.1.3. Roles and interactions in the Brazilian system of innovation

The second part of the semi-structured interviews investigated perceptions of what the relative roles of public and private agents and institutions should be in the Brazilian system of innovation. We asked how the relationship between

these agents/institutions could be characterized and about the experience of the interviewees in interacting with other agents/institutions.

There was relative consensus that the state should induce or *direct* the private sector to invest in R&D and innovation through systemic policies, including "a strategic vision with clear objectives and incentives [to] unite and coordinate different institutions geared toward the same goals", in the words of a multinational director. "Aligning" public and private interests and "attracting" business to the innovation process – words that appear in Figure 6 – reflect this shared perception.

Figure 6: Quality of interactions the Brazilian system of innovation – top 20 words

Source: Authors' construction.

Interviewees viewed the role of the state as being complementary to that of business; in this sense, one interviewee from MCTI argued that "[t]here are no necessary and sufficient roles. There's no frontier that divides what should be done by the public or the private [sector]. There's complementarity between the public and the private." A senior representative of BNDES noted that "even critics agree that [promoting R&D, entrepreneurship and innovation] is an area for BNDES to invest … Sure, we would like to do more in this area … The difficulty is finding companies willing to invest in innovation." This highlights another perception, namely that the extent of the state's role in the Brazilian NSI depends on the sector. In some sectors (production chains) where domestic firms hold strategic assets and competences, business should be able to take on bigger risks. These include oil exploration, biofuels, Embraer's

production chain, transport and engines, agribusiness, health, and public services through automation.

With regard to how to characterize the quality of interactions between public and private agents (see also Figure 6 above), all interviewees agree that the heterogeneity of the Brazilian economy does not allow for a general characterization of the interactions as being “symbiotic” (all agents share risks and profit from mutual actions), “parasitic” (some agents profit more from the actions of others than vice-versa), or “antagonistic”. The feeling is that “political interests sometimes lead to parasitic and antagonistic situations”, as one business director argued. However, in some sectors and between some institutions, interactions tend to be more symbiotic and constructive. Some positive examples cited were health, biofuels/ethanol, agriculture, and aspects of the Brazilian space program. In particular, there is a perception that the models adopted for the health sector could be expanded and emulated in other sectors.

Interviewed businesses shared their experiences of interacting with public (or semi-public) institutions, which they considered to have been positive, particularly with BNDES, FINEP, ABDI, Embrapii, regulatory agencies (in the case of the interviewed electricity companies), and with universities. However, a director of a multinational enterprise observed: “there is plenty of goodwill [in the public sector]. But there is a mad bureaucracy that leads to slowness in decision-making…. Some internal coordination and efficiency is needed to align [the goodwill] with these [actual] goals and processes.” Furthermore, specific agencies and public processes are seen as overly bureaucratic and sluggish. An example is the intellectual property process at INPI and the process for importing R&D machinery and inputs. Despite the positive interaction with universities, there is, as already stated, a perception among businesses that academia is very much self-oriented, which impairs the quality and effectiveness of interactions.

In sum, the shared perception of the representatives from public, private, and academic institutions is that the private sector needs to step up its innovative strategies in order to fulfill its own potential. The state could help by strategically using its toolbox of public policy instruments.

5.1.4. Issues for public policies to address

The third part of the semi-structured interviews addressed topics related to public policies and policy instruments. Here we report the key points that came up regarding public policies and the barriers to innovation (Figure 7). We then

discuss the interviewees' perceptions of the relative effectiveness of financial and non-financial policy instruments.

Unlike most of the other questions, no clear consensus emerged from the interviews regarding what the main issues were for public policy to address. Each respondent highlighted the need to address a different issue, which could be due to the problems their own institutions face. Some of the issues and barriers cited include: low participation of the private sector in the venture capital industry, difficulty finding the right (private and public) partners to carry out R&D projects, and internal resistance to risk-taking and innovation in public institutions.

Figure 7: Issues for public policies and barriers to innovation – top 20 words

Source: Authors' construction.

In their responses, public and private agents pointed to the following barriers to innovation (internal and external to the institutions):

a) The legal environment for innovation needs to be improved and provide more institutional security (less bureaucracy, for opening/closing business, importing equipment, applying for patents and new drugs; more logical tax structure; a positive macroeconomic policy agenda). Furthermore, this entails clearly defining the relative roles of each public institution; for example, a clearer division of labor between BNDES and FINEP and between FINEP and CNPq. In particular, public agents called attention to the fact that Law 8666 (the public tendering law that stipulates a competitive, lowest-price process for public procurement) is

an important barrier for the state to effectively use its purchasing power to promote innovation development. “The Innovation Law waives the need for a competitive bidding process for innovative *projects*, yet it requires bidding for the innovative *product*. The law is therefore ineffective” (interview with a senior official at MDIC).

b) The state needs to use its capital/resources (for example, sectoral funds – ‘FNDCT’) and policy instruments more strategically, and to guarantee continuation of resource flows, by establishing a clearly defined, long-term innovation agenda guided by a vision and mission. However, one senior representative from BNDES argued that the “lack of public planning is a common-sense critique … [the state] needs to define what innovation is for, and then create a vision: is it for competitiveness? Health? Military?” Defining this agenda is not straightforward and requires the participation of society at large, which also involves promoting this agenda with stakeholders (for example through awareness-raising campaigns).

c) The state still needs to improve basic education while also promoting technical training and an entrepreneurial spirit. In particular, with regard to the entrepreneurial culture, a director from a multinational enterprise called for the state to “promote the mindset of innovation; the way it is handled [in Brazil] is counterproductive. Mistakes and failures should be valued for the learning experience, as in the Anglo-Saxon model, and not condemned … What is needed is a long-term cultural [education] project to change the mentality through debate in society.”

d) The state should actively foster business-academia partnerships by, as a senior CNPq civil servant claimed, “identifying competences and capabilities that already exist in the Brazilian system of innovation; promoting knowledge about how to bring S&T centers closer to business and vice-versa; and showing society what is being done and achieved”.

Regarding financial instruments, there is a shared perception that Brazil has almost all the instruments in place – subsidies/subventions/grants, subsidized credit, equity, tax incentives – but there is a lot of overlap between institutions granting them. Furthermore, they are not used strategically, and interviewees agreed that each instrument may be more effective for a certain stage of the innovation process, and according to the type of project, institution or sector. “Given the heterogeneity of the Brazilian innovation system, policies that target ‘the average’ are doomed to failure” (interview with a senior officer at MCTI). Subsidies and grants would be more effective for the early stages of the

process when uncertainty is highest. Equity (through public-private VC funds) would be more appropriate in support of innovative start-ups (which often lack guarantees) or riskier projects with the prospect of windfall gains. Subsidized credit would be suitable for more mature projects and bigger firms.

Although there is a perception that tax incentives (provided by *Lei do Bem*) are not very effective in the promotion of new innovation projects, the establishment of these incentives did help to promote an innovation culture within big companies. In particular, they represented a paradigm shift in the way the public sector deals with businesses, because projects seeking the incentive do not need to be pre-approved by the public sector (as is mostly the case when applying for public funds in Brazil). As a representative from the private sector noted, "there's a presumption of good faith."

Another consensus that emerged is the lack of a legal framework allowing for the state to promote strategic procurement for innovation, which has been called "a fantastic instrument". A senior MDIC officer explained that "the current system is focused on preference margins for local technological content, and less for technological development and innovation. For example, Petrobras fosters start-ups without being able to acquire from them; the same happens with public banks." The single procurement regulation for all type of public institutions is perceived as counterproductive, because it prevents state-owned enterprises from using their purchasing power to promote innovations and public universities/research institutions from acquiring state-of-the-art equipment and inputs.

Figure 8 shows the word cloud for the answers on the effectiveness of non-financial policy instruments. There's a shared perception, both among the institutions themselves and with other actors, that public financial institutions like BNDES and FINEP have a 'convening power' and therefore a potential soft role to play in the Brazilian system of innovation. The expertise and experience of these institutions could be used, for example, to identify business needs and competences, as has happened in the Inova programs. Interviewees also indicated some types of non-financial policy instruments that have the potential to be used more. These include technological parks to bridge academia and businesses, training of professionals, establishment of innovation networks, and initiatives such as those spearheaded by Embrapii.

Figure 8: Non-financial policy instruments – top 20 words

Source: Authors' construction.

The interviews also raised questions about the level of private investment in innovation in Brazil, which is perceived to be very low, and whether public investments in R&D and innovation tend to crowd out private investments. All interviewees tended to agree that this was not the case, given the low propensity of the private sector to invest in innovation and the tendency for businesses to shy away from the riskiest projects. However, respondents from the private sector shared the perception that the non-strategic use of subsidized credit would crowd out private investors. As one of the private sector interviewees argued: "There are sectors in which the private investor would not enter, but there are others in which the private could enter … There is no crowd-out by direct [public] investment through venture capital. But credit for certain firms can lead to it."

When discussing the effectiveness of public policies, a recurring theme cited by public and private sector interviewees was the experience with the *Inova* program, which was seen as a very positive initiative. Interviewees' perception of the program's effectiveness was further explored through specific follow-on questions, and also by interviewing BNDES' and FINEP's staff engaged in policy-making, implementation, and evaluation of the program. The main findings from the interviews on the *Inova* program can be summarized as follows:

- The design of the program was innovative, unifying different public agencies, companies, and science and technology institutions around the same mission.

- The program represented an institutional innovation, in particular the partnership set up between BNDES and FINEP, combining their expertise and utilizing their financial instruments strategically. The utilization of project calls was also something new to BNDES.
- The visibility of the sub-programs encouraged business engagement; responses were often higher than expected, even in difficult years for the Brazilian economy.
- While positive overall, some sub-programs were perceived as more or less effective:
    - The sub-programs regarded as most successful were PAISS (2G ethanol) and *Inova Saúde* (health), particularly the sub-lines for medical equipment and for biotechnology. These programs were set up through well-prepared diagnoses and identified specific technologies to be pursued and reposition Brazil relative to the global market. There was a Brazilian scientific base on which to develop the technologies. Businesses were interested in developing and deploying the innovations. There was demand (including, in the case of health, public purchasing power), and there were appropriate instruments. All of the above factors combined to result in a clear mission.
    - Other sub-programs presented more mixed results, for example, *Inova Energia* (energy), *Inova Petro* (oil), and *Inova Defesa* (defense). *Inova Energia* was regarded as being too broad and not well diagnosed. Some of the sub-lines, like smart grids, resulted in interesting projects, but others, like hybrid car technology and solar and wind energy technologies, were selected without a deep analysis of the global supply chain and the Brazilian production base. Furthermore, despite the involvement of the electricity sector regulatory agency Aneel (regarded by business as positive), policy tools were restricted to financial instruments. Inova *Petro* was based on a good diagnosis, given the involvement of Petrobras, which shares its technological needs, but the state-owned oil company could not ultimately guarantee the acquisition of the innovative technologies. A similar issue affected *Inova Defesa*: defense is a government purchase sector, but despite the armed forces contributing a vision and a definition of the technologies, there was no public purchase guarantee. Ultimately, Brazilian defense companies shied away.
    - The sub-program regarded as the least successful was *Inova Sustentabilidade* (sustainability), whose goal was too ‘open’ and too broad in terms of technological goals, vision and mission. This

meant that it attracted an array of weak projects that neither BNDES nor FINEP could properly filter.

- The model employed for the successful first program (PAISS) was copied and adopted to other sectors with little adaptation. This 'one size fits all' approach was one of the reasons for the mixed results. Furthermore, some sub-programs were established too quickly, due to political pressures, so that there was little time to undertake a proper diagnosis.

All in all, the *Inova* program was regarded in the interviews as a type of *mission-oriented policy* that should be improved and expanded.

5.1.5. Risks and rewards, missions and inequality

The fourth part of the semi-structured interviews addressed three questions: (i) how to share risks, rewards, successes and failures between public and private agents; (ii) the key missions and challenges for Brazil; and (iii) how innovation policies could contribute to tackling socio-economic inequality.

(i) Risk Sharing

Interviewees agreed that the potential issue of risks of innovation being borne by the state while the private sector reaps the rewards was not an important problem in Brazil. The main public financier of projects, BNDES, funds projects through refundable instruments (credit; equity) and therefore shares the rewards. Furthermore, in the case of specific programs and projects, other public institutions are able to share property rights. Finally, interviewees tended to see the positive externalities and the non-pecuniary impacts of R&D and innovation as a form of societal reward.

The issue of how the public sector should deal with failures associated with the innovation process was discussed in depth by public sector interviewees. Business representatives also shared their views. They all recognize (Figure 9) that risk is inherent to the process, which means that failures will happen and should be accepted. The view of a senior officer at MDIC that "the key is learning and monitoring" was widely shared. Two public institutions – Fiocruz and Embrapa – shared the process through which they deal with the issue. Fiocruz tries to develop its own metrics to evaluate success and failures. Like pharmaceutical companies, they rely on dynamic assessment methods and a focus on problem solving.

Figure 9: Risks, rewards, successes and failures – top 20 words

Source: Authors' construction.

Embrapa employs a continuous performance management system [21] that provides guidelines for all the different research agendas it develops. "To reduce the probability of failure, the first step is a good performance management process". Furthermore, Embrapa adopts a multiannual *portfolio approach* to its projects, with medium and long-term goals. Projects are managed jointly and are dynamic, in line within the portfolio's goals. Resources are used strategically – when one project fails, another may enter the portfolio. It is worth noting that all private sector interviewees mentioned the use of a portfolio approach as a way to deal with the risk of project failure in the public sector.

(ii) Key missions and challenges

The challenges and missions seen by interviewees as the most important for Brazil's long-term innovation agenda (Figure 10) were:

[21] Embrapa has a "very sophisticated" process management system (called SEG – "Sistema Embrapa de Gestão"/Embrapa Management System) that the president can access from his computer. It is automated/computerized and was created within Embrapa (through collaboration between the agricultural information unit and the IT department). This is an interesting example of public sector in-house innovation.

Figure 10: Key challenges and missions for Brazil – top 20 words

Source: Authors' construction.

- Energy: **renewable energy**, particularly biomass (but also wind and solar energy, specifically components and/or associated services); **oil and gas exploration** in ultra-deep sea and beyond the salt layer in the bottom of the ocean (pre-salt reserves); **smart-grids** and network modernization to promote energy efficiency and security of supply.
- Urban infrastructure: urban mobility, housing, smart cities, disaster monitoring (particularly floods, and also in rural areas).
- Public service and public infrastructure: technologies for health, education and training, and other elements of the Brazilian welfare state; and technologies that could help improve public sector efficiency.
- Agriculture, including: technologies for socially, economically and ecologically sustainable food production, including the strategic use of water, energy, and other natural resources. This mission could include the use of biotechnology and draw on Brazil's biodiversity.
- National security: aerospace, defense, and cyber security.

(iii) Tackling socio-economic inequality

The final topic of the interviews concerned whether and how innovation policies could contribute to tackling socio-economic inequality (Figure 11). The perception is that innovation policies can and do contribute to diminishing inequality amongst individuals and regions. Brazil actively aims to do this, for example, through requiring investments in the poorest regions of the country

(North, Northeast, and Center-West regions). Helping to address regional inequality is part of the mandate of such agencies as Fiocruz, Embrapa, and BNDES.

Figure 11: Innovation policy and socio-economic inequality – top 20 words

Source: Authors' construction.

However, some interviewees (from both the private and the public sector) noted that such requirements may be counterproductive and ineffective, if those regions lack the appropriate infrastructure and skilled human resources. Therefore, investment in infrastructure and skills is crucial if innovation policies are to effectively help to address inequality.

Finally, it was noted that some of the potential missions for Brazil – those connected to the provision of welfare services, public goods, and urban infrastructure – would intrinsically help to address inequality and promote socio-economic inclusion.

6. Building a mission-oriented policy agenda for Brazil

Brazil's current political and economic situation poses a huge challenge in a country whose socio-economic development is still incomplete. Corruption scandals seem to have frozen the agenda in Congress, preventing the passage of bills that are important for innovation and economic development, such as reform of the tax code or changes to procurement legislation to allow the strategic use of public procurement for innovation. Against this background, any recommendation that requires legislative changes seems unlikely to be implemented in the near term.

In addition, the federal government has decided to implement an austere macroeconomic policy program, despite evidence that such pro-cyclical policies have not succeeded in other countries (IMF, 2012). Therefore, policy recommendations will need to consider the limitations imposed by a limited public budget for public investments.

Notwithstanding these obstacles, it *is* possible for Brazil to establish a positive long-term agenda for development and sow the seeds for transforming its national innovation system to be more mission-oriented. Through this study, we hope to be able to contribute to the formulation of this agenda. To this end, we start this section by summarizing the findings from the mapping of the Brazilian innovation system and the interviews. We then propose possible lines of actions to structure a long-term mission-oriented policy agenda – including challenges to be addressed in order to help tackle some of the persistent problems in Brazil, while also making the country a leader in new technological fields.

Findings from the mapping exercise and interviews seem to match in terms of the strengths and weaknesses of the Brazilian innovation system. Strengths were identified as follows:

- The presence of all the elements of a developed system of innovation;
- A subsystem of scientific research that has substantially improved in the last few decades and is producing frontier knowledge in some areas, with 'islands of productive excellence' in sectors such as oil and gas, aviation, agriculture, health, and, to a lesser extent, banking automation;
- Strategic natural assets (e.g. mineral and water resources, plus biodiversity of Brazil's six land biomes and its maritime biome) that in the long run will be increasingly demanded as the process of economic inclusion goes forward in emerging economies;

- A multifaceted state apparatus of agencies devoted to the promotion and execution of science, technology, and innovation policies, including a full toolbox of supply- and demand-side instruments;
- A strong domestic market for mass consumption, which has grown as a result of socio-inclusion policies;
- Public financial resources for R&D and innovation that (in principle) are not affected by budgetary fluctuations or cuts, such as the sectoral funds and the funding from BNDES that does not come from the Treasury;
- Positive examples of systemic 'mission-oriented' policy initiatives, explicitly or implicitly focused on innovation, that lead to positive interactions between the state, the business sector, and academia. These include the *Inova* program, health policies, and, to a lesser extent, initiatives spearheaded by Embrapa and Petrobras.
- Existing complementary policies that may work as enablers of mission-oriented policy programs in national defense and security, and in climate, environment, and energy.

As regards weaknesses, the Brazil system of innovation:

- lacks a consistent long-term strategic agenda (a vision) that gives coherence to public policies carried out by the different public institutions and gives direction to scientific research and to private agents in their innovation efforts;
- displays fragmentation (even antagonism) between the subsystem of education and research and the subsystem of production and innovation, due to the self-orientation of scientific research, and a lack of demand from business for the knowledge produced in academia;
- displays a low propensity to innovate in the subsystem of production and innovation - business expenditure on R&D (BERD) is very low, reaching just 0.50 percent of GDP in 2013;
- suffers from inefficiencies in the subsystem of policy and regulation, specifically: overlapping responsibilities, competition for and non-strategic use of resources, discontinuity of investments and programs, excessive bureaucracy, and control (auditing) of innovation policies and programs, including procurement, in the same way as for other programs;
- requires important institutional reforms in the taxation and regulation of business; and
- is constantly negatively affected by the implicit policies represented by the macroeconomic agenda.

This list of strengths and weaknesses should not surprise those familiar with the Brazilian system of innovation, as they represent the most common diagnosis of academic experts and other stakeholders. They have long been the focus of public policies, either to build on the strengths or to address the weaknesses. Our analysis of Brazil's *explicit* innovation policies (that is, those led by MCTI and encapsulated in science, technology and innovation policy plans) suggests that previous policies have failed due to being based on a restrictive market failure perspective. This led to *ad hoc* and non-systemic projects (many of which had a science-push bias), with the notable exception of the *Inova program* and innovation policies for the health sector. So far, however, science–push policies (like the establishment of technological parks) have had little positive impact on the structure of production or the propensity of firms to innovate.

The study also analyzed the *implicit* innovation policies that are represented by Brazil's macroeconomic regime, and *complementary/enabling* policies, namely: health, defense, socio-economic inclusion, education, climate, environment, and energy.

- Brazil's macroeconomic policy framework of inflation targeting, exchange rate fluctuation, primary surpluses, and expenditure cuts (austerity policies) tends to impair the effectiveness of explicit industrial and innovation policies. This does not mean that innovation policy attempts will necessarily be in vain, but it does mean that public resources for R&D and innovation and innovation policy instruments need to be used strategically.
- Brazil's health strategy is a well-developed state-led policy that has been able to mobilize a range of public and private actors to develop science- and technology-based innovations. Unlike other sectors, the health sector has been able to foster partnerships between government, business and academia. It can be seen as a systemic mission-oriented strategy, with the use of regulation and public procurement complementing public investments and public-private partnerships in health innovation.
- While the National Defense Strategy represents an enabling framework for the establishment of mission-oriented programs, the effectiveness of these programs requires public policy measures to be fine-tuned to the industrial and technological challenges of the Brazilian defense sector.
- There is great potential in the association of socio-economic inclusion and education policies with the policies to promote entrepreneurship and microcredit within the scope of local productive arrangement (APL) and

regional development policies. The inclusion of social classes with lower income and the focus on the domestic market has yielded positive outcomes, resulting in the inclusion of vast portions of the Brazilian population and greatly increasing the potential market for consumer goods – and innovation.

- While they do not yet have a systemic design, Brazil's National Policy on Climate Change (NPCC) and associated environmental and energy policies are an enabling legislation for the establishment of mission-oriented innovation programs to address environmental challenges.

Recommendation 1: Macroeconomic policies and complementary policies could be made more supportive of explicit innovation policy programs.
Recommendation 2: There are some inefficiencies in the subsystem of policy and regulation that require legislative action – such as reforming the complex Brazilian tax system or removing the barriers to implementing public procurement for innovation.

We do recognize, however, the difficulties of promoting this legislative agenda in current circumstances and therefore our further recommendations will focus on actions that may not require legislative action. One strength and one weakness identified above point to a possible strategy that can help address the key barriers for the Brazilian system of innovation to thrive. These are the existence of positive cases of what can be regarded as mission-oriented policy programs and the need for a consistent long-term strategic agenda that gives coherence to public policies and a direction to research and innovation. We will expand on these points, based on theories discussed in Section 3, to propose a mission-oriented policy agenda for Brazil. Well-defined missions provide the *directions* in which the subsystems and their actors will evolve to meet societal demands. They help consolidate subsystems by transforming metaphorical 'islands' of excellence into 'archipelagos' of socially recognized excellence.

Looking at the two examples of relatively successful mission-oriented policies in Brazil – the policies for the health sector and the *Inova* program – we can ascribe the success of these programs to the presence of six crucial characteristics:

i. **Scientific-technological capacity:** an appropriate scientific and technological knowledge base in the subsystem of education and research;
ii. **Demand capacity:** latent or effective (public or private) market demand, in terms of both purchasing power and need;

iii. **Productive capacity:** an appropriate business base (for example, existing firms or entrepreneurs willing to take risks to establish an innovative firm) in the subsystem of production and innovation;
iv. **State capacity:** appropriate knowledge inside the public organizations formulating and executing the policies about the problem and solution being targeted and/or knowledge about who-knows-what-and-how;
v. **Policy capacity**: appropriate supply-side and demand-side policy instruments (strategically deployed), supported by complementary policies;
vi. **Foresight capacity:** a fine-tuned diagnosis of the problem and solution, including an analysis of the current situation and future prospects for targeted technologies and sectors, formulated in terms of a well-defined mission and vision.

Successful mission-oriented policy experiments in Brazil had all six factors in place (Box 8) whereas in less successful areas, at least one of the six capabilities was lacking (Box 9).

Not all capacities need to exist a priori; they may be created during the mission-oriented policy process itself – including foresight capacity, which can be developed through fine-tuning the diagnosis of a societal or technological challenge. Three mechanisms (more or less present in the successful *Inova* sub-programs and in the Brazilian health policies) facilitate the creation of capacities during the mission-oriented policy process itself. These are (1) mechanisms promoting cooperation, amongst, for example, research labs, research and business, business consortia; (2) mechanisms for competition, for example, the open 'call for project proposals' of the *Inova* program; and (3) mechanisms for evaluation and accountability, which prevent deviations from program and, more crucially, allow for learning and knowledge accumulation.

Recommendation 3: Mechanisms for competition, cooperation, and accountability should be established and reinforced in mission-oriented policy programs, in order to help balance the relative roles of state, business sector, and academia.

Box 8: Examples of successful mission-oriented policy in Brazil

Health policies had the following six characteristics conducive to success:

- scientific-technological capacity – an excellent knowledge base created by Fiocruz, university labs, and business R&D departments;
- demand capacity – drawing on the purchasing power of SUS and Brazil's existing needs for medicaments or equipment;
- productive capacity – the existence of a growing number of domestic firms that benefited from the active support given by BNDES Profarma;
- state capacity – the knowledge inside state organizations, such as the Ministry of Health, Fiocruz, Anvisa, and BNDES, and in the universities;
- policy capacity – a range of policy tools, such as public procurement, financial incentives, equity support, brokerage of information, regulation, and standards, establishment of specific networks through the PDPs;
- foresight capacity – a unifying mission of improving Brazilians' welfare by promoting access to healthcare service and to medicines and a vision of universal access to health, with specific indicators of success.

Two sub-programs of *Inova* have been regarded as very successful: *Inova Saúde*, whose success is also due to the reasons given above; and PAISS, for which it is also possible to show that all six capacities existed. In relation to PAISS, however, demand capacity was not represented by public purchasing power and need, as in the health policies case, but by potential demand from the flex fuel market for 2G ethanol and by the need to upgrade existing productive facilities.

Source: Authors' elaboration.

Box 9: Examples of less successful policies

The less successful Inova programs lacked at least one of the six capabilities. For instance, *Inova Petro* and *Inova Defesa* both lacked demand capacity, as neither Petrobras nor the Ministry of Defense/Armed Forces could guarantee purchase of the developed technologies. *Inova Energia* also lacked policy capacity due to a lack of coordination with other policies such as energy auctioning and tariff policies, as well as a lack of demand capacity (as in the case of hybrid and electric vehicles), and a lack of a proper diagnosis – the foresight capacity – that translated into a mission or a vision. Consequently, *Inova Energia* failed despite having some scientific-technological and productive capacities, and state capacity, although these were dispersed throughout the energy public policy system and apparatus. *Inova Sustainability* seems to have been the one program where all capacities were lacking, except perhaps the scientific-technological capacity, but without a well-defined mission to give direction to the scientific effort.

Source: Authors' elaboration.

These findings *and analyses r*egarding the capacities are very relevant. They provide the basis for a template that can be extended and developed in more depth, and later applied in the evaluation of other mission-oriented programs in Brazil.

Recommendation 4: In the light of the findings from this report, a detailed (re)evaluation of Brazilian 'mission-oriented' policy experiments should be carried out, as these experiments represent rich opportunities for institutional learning by the public agencies concerned.

As we argued in Section 3, a public organization's ability to experiment, explore and learn is key for a successful entrepreneurial state. Therefore, the successful features of learning organizations in Brazil should be emulated in other public agencies. Emulation does not mean 'copying' the features with no attention to context or transferability. It requires that the party attempting to emulate takes account of existing contexts, capabilities, competences, and constraints. Successful features of learning organizations can be emulated by creating mission-oriented networks and partnerships that draw on the strengths of each partner. This kind of network arrangement, with distributed competences but well-defined responsibilities, can also help address one of the inefficiencies of the policy and regulatory subsystem, which is fragmentation of the state apparatus and overlapping of attributions of public agencies.

Recommendation 5: Successful features of learning organizations should be emulated in other public agencies, taking account of context, capabilities, competences and constraints, by creating mission-oriented networks and partnerships.

In this sense, the example of the *Inova* partnership between BNDES, Finep, ministries, regulatory agencies, and SOEs is positive. Indeed, we believe that public financial institutions like BNDES and Finep are well-suited to leading and coordinating the process of formulating, implementing and evaluating mission-oriented policy, due to their structure and their accumulated experience in interacting with business and academia in many different industrial sectors and scientific fields.

So, what are the key missions that will help Brazil address pressing problems and become a technological leader in some fields? Before we indicate a list of potential missions for Brazil, we consider *how such missions should be defined* and the *characteristics of a good mission*. The following list of do's and don'ts of mission-oriented policies is derived from the literature discussed in Section 3 and insights from the interviews:

- **Missions should be defined through a democratic process so that they are perceived as legitimate and stakeholders share a sense of ownership.** They should be based on a relative consensus, which is difficult but not impossible to form. This entails bottom-up involvement from businesses and academic stakeholders, and (when warranted) from society at large.
- **Missions need to draw on a country's expertise, advantages, capabilities, and competences, both scientific and productive.** They should also allow the country's people to develop and fulfill their creative and intellectual potential.
- **There should be a mixture of medium-term (problem-solving) missions and long-term (technological leadership) missions.** Some missions should generate knowledge that is not just for the knowledge pool, but, more crucially, for addressing a societal problem or challenge. Other missions should allow a country like Brazil to become a technological leader in the long term. The most strategic missions are those that are able to combine both.
- **The missions should be structured so that they engage the private business sector, motivating it to take a leadership role in innovation.** This is particularly important for Brazil, where historical mission-oriented projects (such as conquering of *Cerrado*, oil production) always had state-owned companies investing, leading, and executing the projects. The challenge is to have business take on these tasks in partnership with the public sector and the academic sector.
- **As missions should motivate and provide incentives to the private business sector, they should also specify counterparts in return.** This includes defining how the risks and rewards from the innovation process (for example, IP rights) will be shared by the stakeholders.
- **Missions should be well defined and not overly abstract.** More granular definition of the technological challenge facilitates the establishment of intermediate goals and deliverables, and processes of monitoring and accountability. When governance is too broad, it can become faulty, and there is a risk of being captured by vested interests.
- **A mission does not comprise a single R&D or innovation project, but a portfolio of such projects.** Because R&D and innovation is highly uncertain, some projects will fail and others will succeed. All concerned should be able to accept failures and to use them as learning experiences. Furthermore, stakeholders should not be punished because of failures derived from good-faith efforts.

- **Missions should result in a trickle-down effect**, whereby the priorities are translated into concrete policy actions and instruments to be carried out by all levels of the public institutions involved. While these missions should involve a range of public institutions, it is crucial that there is a strategic division of labor amongst them, with well-defined responsibilities for coordination and monitoring.

These considerations point to the need to adopt a pragmatic approach to defining missions, particularly in times of austerity.

Recommendation 6: The missions chosen should reflect best practice, as set out in this report. They should be feasible, draw on existing public and private resources, be amenable to existing policy instruments, and command broad and continuous political support. Missions should create a long-term state agenda for innovation policies, address a societal demand or need, and draw on the high potential of the Brazilian science and technology system to develop innovations.

To a certain extent, providing a straightforward list of missions for Brazil contradicts the core element in successful mission-oriented programs. Missions should be determined through a fine-tuned diagnosis of the problem and solution that involves stakeholders and draws on the strengths of the Brazilian system of innovation and considers ways to overcome its weaknesses. Nevertheless, we believe that the mission ideas that emerged from the interviews, drawing on the distributed knowledge of the interviewees, do represent areas where the country possesses complementary assets (in the form of natural, scientific, technological, and/or productive resources) and on which the Brazilian state should focus further diagnosis.

Recommendation 7: As well as continuing, improving and expanding successful ongoing mission-oriented initiatives – health policies and the *Inova* program – we recommend that detailed diagnoses and prognoses – with the identification of existing capacities and of those that will need to be created – be prepared for other potential missions.

These missions might include:

- **Urban, suburban and interurban infrastructure**, which would help improve the quality of life in Brazilian cities and improve productivity.
- **Public service and public infrastructure**, which would help address the inefficiencies in public services and also improve productivity.

- **Agribusiness and familiar agriculture**, which would add value to Brazilian agriculture and could make Brazil a leader in sustainable production (with potential technological spillovers to other domains).
- **Energy and the environment**, which would draw on Brazil's biodiversity and natural resources and could make Brazil a leader in renewable energy and biotechnology.
- **National security,** due to its synergies with other missions, given the potential dual use of technologies developed for military purposes.

These potential missions could play a central role in a network of innovation solutions associated with industry- and service-related economic activities. We also recognize that we have indicated rather broad missions (or strategic areas) that may need to be broken down into sub-areas and challenges before being formulated into well-defined missions. Finally, while the first two missions are directly related to Brazil's challenge of addressing socio-economic inequality, all others may include tackling inequality as an integral dimension.

Recommendation 8: Missions should, where feasible, be designed in a way that contributes to tackling inequality. Some will do this directly, others indirectly. In some cases, complementary investment in infrastructure and skills will be required if innovation policies are to be effective in addressing inequality.

Altogether, our recommendations represent an alternative agenda to the policies currently in place in Brazil. A mission-oriented policy agenda would increase the effectiveness of innovation policy and also has the potential to help rebalance public finances, not by cutting expenditures – as in the prevailing austerity agenda – but by increasing strategic investments that, due to the higher multiplier effect, would increase future revenues. By engaging in a mission-oriented policy effort, Brazil should again be able to define the direction and ambition of its own development trajectory.

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ANNEX I: Description of key actors in the Brazilian National System of Innovation

AI.1. Subsystems of production and innovation

AI.1.1. Private enterprises

Brazil has a heterogeneous production base that is comprised of both domestic and multinational corporations. The private business sector displays a low level of investments in R&D and innovation, but there are some exceptions, especially in the consumer goods sector. Rankings of Brazil's most innovative private companies often include Natura (cosmetic products), Bradesco (banking), Totvs (software/automation), WEG (electric equipment), Gerdau (steel), and the previously state-owned Embraer (aeronautics) and Vale (mining). The majority of private corporations and firms are micro-enterprises and SMEs, which are relatively invisible actors in the Brazilian national system of innovation due to the high level of informality that characterize their operations. Micro-enterprises (which have fewer than 10 employees) are excluded from innovation surveys, despite being an important source of innovation. On average, micro, small and medium enterprises (MSMEs) display a high level of informality (for example, they do not conform to official regulations or accounting standards), which prevents their access to public finance, thus leading to financial limitations that prevent their engagement in financial activities. The informality of MSMEs also characterizes their cooperation practices, which means they are not captured by some official statistics. Despite these caveats, data discussed in Section 4.1. show that the recent expansion of the aggregate innovation rate in the Brazilian economy (as well as the decline in the last survey) can be seen mostly as a phenomenon of SMEs.

AI.1.2. State-owned enterprises (SOEs)

Brazilian state-owned enterprises display a relatively high propensity to invest in R&D and innovation compared to private enterprises. These SOEs includes some of the most innovative companies in the Brazilian economy, which is related to the fact that many of them have their own research centers. The Brazilian oil company Petrobras is a world leader in deep–sea oil exploration and continues to invest in capacity building through its research center CENPES and in cooperation with suppliers and other science and technology institutions. Petrobras took part in the elaboration of the innovation policy programs lead by FINEP and BNDES *Inova Petro 1 and 2*, helping to define which technologies were to be targeted. The utility company Eletrobras

(production, transmission and distribution of electricity) is also regarded as one of the top innovative firms in Brazil, developing innovation through its own research center CEPEL.

AI.1.3. Industry associations

National Confederation of Industry (CNI): The National Confederation of Industry is the official industry trade association of Brazil. In recent years, it has promoted an innovation agenda in order to improve competitiveness of Brazilian industry. CNI is responsible for the organization of annual Industrial Innovation Congresses. In 2009, CNI organized an action program called *Mobilização Empresarial pela Inovação* (MEI – Business Mobilization for Innovation), which aims to stimulate innovative strategy of Brazilian companies and increase the effectiveness of policies to support innovation by establishing dialogues between the private sector and the public sector. MEI promotes studies and strategies that seek to sensitize both sectors to the relevance of innovation to business competitiveness and national development. Through working groups, publication of studies, workshops, and meetings, MEI seeks to actively influence business strategies and public policies for innovation. The initiative is supported by a Business Leadership Committee comprised of CEOs and directors of Brazil's most important national and multinational companies, of different sizes. This committee meets periodically with representatives of the federal government and public agencies to discuss the innovation policy agenda.

National Association for Research and Development of Innovative Companies (ANPEI): ANPEI was founded in 1984 as an outcome of an annual meeting of R&D executives from various business enterprises. Its mission is to promote the idea of innovation as a key to business and economic development.

AI.2. Subsystem of education and research

AI.2.1. Universities

According to national rankings (for example, *Ranking Universitário Folha*) and international rankings (such as the QS World University Rankings), the top Brazilian universities are all public. *Universidade de São Paulo* (USP) is funded by the state of São Paulo and is recognized as Brazil's leading institution (ranked 143rd in the QS World University Rankings 2015). *Universidade Estadual de Campinas* is another leading institution maintained by the State of São Paulo (195th in the QS World University Rankings 2015). Other top institutions are maintained by the federal government, including *Universidade*

Federal do Rio de Janeiro (UFRJ) (the only other Brazilian university ranked amongst the top 400 in the QS Rankings), *Universidade Federal de Minas Gerais* (UFMG), and *Universidade Federal do Rio Grande do Sul* (UFRGS). Among private institutions, the Catholic Universities of Rio de Janeiro (PUC-Rio) and of Rio Grande do Sul (PUCRS) are the only ones to appear in the top 20 universities in the *Ranking Universitário Folha 2015*.

AI.2.2. Public research institutions

Apart from research conducted inside public and private universities, Brazil has a system of public research institutes comprised of institutions of excellence that contribute to the dynamism of certain sectors of the economy. The most prominent institutions are:

- The Technological Institute of Aeronautics (ITA) and the Technological Center of Aeronautics (CTA), key agents in the Brazilian aircraft innovation system and crucial for the success of Embraer;
- The R&D center of Petrobras CENPES;
- Embrapa (agricultural and biotech research);
- The National Institute for Space Research (INPE), which works closely with the Brazilian Aerospace Agency (AEB), associated with the Ministry of Science, Technology and Innovation, which is responsible for responsible for formulating and coordinating Brazil's space policy;
- The National Commission for Nuclear Energy (CNEN);
- Fiocruz (biological and biomedical research), a leading research institution in tropical and neglected diseases (among other fields);
- The Center for Research and Development in Telecommunications (CPqD), which was previously linked to the state-owned telecommunications firm Telebras, but became an independent institution with the liberalization and privatization of the Brazilian telecommunications industry.

AI.2.3. Vocational education institutions

The most important actors in the system of vocational education and adult training are the nine so-called 'S' institutions that provide training service (thus the 'S') to specific professional categories/sectors. The most important and active of these institutions are SENAI (training for workers of industry/manufacturing sector), SEBRAE (coaching for small and medium entrepreneurs/enterprises), and SENAC (training for workers in the service sector). The 'S' system is funded by compulsory contributions from firms to the industry associations that manage each 'S' institution (for example, the National Industry Confederation/CNI manages and funds SENAI). Another important

institution that can be seen as part of the professional training system is the *Instituto Euvaldo Lodi* (IEL), which was created in 1969 to promote vocational training through internships for students in companies. Since the 1990s, IEL has modified its line of action to focus on business, entrepreneurial, and innovation management training. IEL is currently responsible for the executive coordination of CNI's business-led innovation initiative MEI (Business Mobilization for Innovation).

AI.3. Public and private funding

AI.3.1. Private banks

Brazil's banking system is composed mostly of universal banks; that is, those that provide both commercial and investment services. This development resulted from government policies from the late 1980s that opened the sector up to competition and led to wide participation of foreign banks. The five largest private banks in Brazil by asset size are *Itaú*, *Bradesco*, *Santander*, *HSBC*, and *BTG Pactual* (an investment bank).

AI.3.2. Public banks[22] and research and innovation funding institutions

BNDES: The Brazilian development bank BNDES is the most important funding agency for long-term projects in Brazil. In the mid-1990s, BNDES experimented with programs aimed at R&D and technological innovation development, but it was after 2003 that it increased its disbursements and programs for innovation projects. Indeed, the support for innovation became a strategic priority at BNDES following the 2003 Brazilian industrial policy plan (PITCE), when innovation was converted into the key variable in BNDES's Operational Policy document. By 2006, BNDES became more involved in the design and implementation of specific policies for the promotion of industrial development and technological innovation (Cassiolato *et al*., 2014). It designed several programs specifically in support of innovation, such as the Innovative Capital program, which supports innovative firms through equity investments; the Productive Innovation program, which provides subsidized credit to innovative projects; and the Technological Fund FUNTEC, which provides non-reimbursable funding for research and development in strategic areas. Furthermore, BNDES promotes specific programs that target innovation at the sectoral level, such as Profarma (pharmaceutical sector) or Prosoft (software sector), and, with FINEP, executes several *Inova* programs.

[22] Two other public banks that provide funding for productive investments are the state-owned commercial banks *Banco do Brasil* and *Caixa*, which have special lines of credits for agriculture and mortgages, respectively.

FINEP (Funding Authority for Studies and Projects): FINEP can be regarded as a development bank for science, technology, and innovation projects (Martins and Penna, 2015). However, its resources are much lower than those of BNDES. It is responsible for managing the sectoral funds of the Ministry of Science, Technology, and Innovation, which in 2014 disbursed BRL 500 million to various STI projects. FINEP funds R&D and innovation through two broad types of tools: reimbursable loans and non-reimbursable grants. Since 2012, FINEP has established 12 priority areas, in line with the federal industrial policy plan, which include aerospace and defense, oil and gas, green technologies, biotech, nanotech, and new materials. Since 2011, FINEP, together with BNDES, has led the execution of the *Inova* programs.

CAPES: Affiliated to the Ministry of Education, CAPES is responsible for expanding and consolidating Brazilian post-graduate programs (as well as being responsible for ensuring the quality of postgraduate programs). To this end, it provides scholarships to master, doctoral, and post-doctoral students pursuing degrees in Brazil and abroad; CAPES also has many programs that focus on human resource capacity building (training) in specific areas from engineering to international relations.

CNPq: Affiliated to the Ministry of Science, Technology, and Innovation, CNPq provides grants for the training of human resources in the field of scientific and technological research, working at universities, research institutes, and technology centers in Brazil and abroad. It provides individual grants (to students and researchers) and research grants (to specific research projects).

Research Support Agencies (FAPs) (state level): At the state level, several funding authorities provides finance for R&D projects. The FAPs utilize state-level resources to finance research, train human resources (including scholarships for students and researchers), build infrastructure, and promote innovation. The most active and best endowed FAP is that of the State of São Paulo (FAPESP).

AI.4. Subsystem of policies and regulations

AI.4.1. Federal government[23]

Ministry of Science, Technology, and Innovation (MCTI): The Brazilian Ministry of Science, Technology, and Innovation was established in 1985, when

[23] Given the national scope of this report, we do not present state- and city-level secretaries.

innovation was placed on the policy agenda for the first time, with new programs being set up in areas such as information and communication technology, biotechnology, and advanced materials. Whilst MCTI was initially able to restore funding for STI programs to the (relatively high) level of the early 1970s, the Ministry faced resource restrictions in the late 1980s and early 1990s and lost prestige, being downgraded to a 'Special Secretariat' until 1992. Innovation returned to the federal government's agenda in the new millennium, but neoliberal influence saw policies that were narrowly conceived, mainly horizontal or, at best, followed a supply–push logic. These policies were restricted to the Ministry itself, motivated by a linear view of the innovation process and conceived as means to correct market failures (Cassiolato *et al*., 2014). The policy focus was on incentives for technological development in firms (mainly, R&D tax credits), promotion and incentives for science and technology infrastructure (in universities and research institutions), and support for technology start-ups (Koeller and Gordon, 2013).

In the 1990s the MCTI funding capacity was restored through the institution of 'sectoral funds'; that is, capital funds whose resources come from public and private enterprises of specific sectors, with 50 percent of the resources earmarked to the R&D and innovation projects of the sectors themselves. There are currently 13 sectoral funds (oil and gas, aeronautics, aerospace, agribusiness, waterways and shipyards, biotechnology, energy, water resources, ICT, mining, health, land transport, and telecommunications); two horizontal funds (one dedicated to the promotion of university-enterprise interactions and the other to the promotion of STI infrastructure); and one fund devoted to the development of the Amazon region. Those funds are managed by Finep the Brazilian public funding agency for R&D and innovation projects.

From 2003 onwards the scope of innovation policy was broadened with the creation of industrial policy plans that increased the level of resources to MCTI. After 2006, innovation became central to the Brazilian development agenda, with the MCTI becoming the central actor in terms of implementing the STI policies of the country's industrial policy plans. Nevertheless, until recently, policies have been affected by issues that have prevented the effectiveness of MCTI's actions(Koeller and Gordon, 2013; Casiolatto, 2015). The policies remained based on a linear view of the innovation process and therefore focused on R&D more than on innovation. Also, they employed the same tools and mechanisms with limited effectiveness; namely R&D tax credits, sectoral funds (used non-strategically), economic subventions mainly to R&D projects, and interest rate equalization (by BNDES). Furthermore, MCTI action was not fully coordinated with the actions of other federal ministries that play a role in the Brazilian national system of innovation (such as the Ministries of Health,

Defense, Mining and Energy, and Agriculture) and STI policies were sometimes constrained by other policies (such as macroeconomic policies). In 2015, MCTI had an approved budget of just BRL 9.8 billion.

The MCTI oversees or is associated with more than 30 other public agencies, including the Brazilian Aerospace Agency (AEB), responsible for formulating and coordinating the Brazilian space policy; FINEP, a funding agency for innovation projects (see section on funding agencies); CNPq, the National Council for Scientific and Technological Development; Embrapii, the Brazilian Enterprise for Industrial Research and Innovation; and CGEE, the Center for Strategic Studies and Management in Science, Technology, and Innovation.

Ministry of Finance: The Brazilian Ministry of Finance (*Ministério da Fazenda*) is, in practice, the most important institution in the federal government. Its policies directly (and indirectly) impact the actions of other ministries by potentially manipulating such key variables of the economy as interest rates, exchange rates, and inflation rates. The ministry also plays a key role, together with the Ministry of Planning, in the elaboration of the annual federal budget. The Ministry of Finance's macroeconomic policies can be regarded as 'implicit' STI and industrial policies (Cassiolatto, 2015), for they may hinder or support the explicit policies. Due to the character that Brazilian macroeconomic policies acquired since the late 1990s, macroeconomic policies tend to *hinder* STI and industrial policies because they are based on the following three pillars: strict inflation targets achieved through manipulation of (high) interest rates (Brazil has some of the highest real interest rates in the world); permanent primary surplus (restrictive fiscal policy) in order to guarantee the payment of public debt interests; and a flexible exchange rate regime, which until recently had led to an over-appreciated national currency[24] that jeopardized the competitiveness of the domestic industry.

Ministry of Development, Industry and Trade (MDIC): The Brazilian Ministry of Development, Industry, and Trade is the federal institution responsible for the formulation, implementation, and monitoring of Brazil's industrial policy plans. It is also responsible for intellectual property and technology transfer policies. Two key institutions of the Brazilian national system of innovation are controlled by MDIC: the Brazilian development bank BNDES and the Brazilian intellectual property agency INPI (see below). In 2015, the Ministry of Development, Industry, and Trade had an approved budget of BRL 3.3 billion (excluding BNDES's budget).

[24] Since 2011, the appreciation trajectory of the Brazilian Real has reversed, which could have concrete implications for the development of the Brazilian industry and the national system of innovation.

Ministry of Education: The policies carried out by the Ministry of Education have a direct impact on the Brazilian system of innovation, as they are key to the so-called subsystem of capacity building. Whilst local and state governments are responsible for basic and primary education, the federal government is responsible for higher education through the Ministry of Education. To this end, the ministry monitors the quality of undergraduate and graduate programs in public and private university, grants funding to research institutions, and awards scholarships to undergraduate and postgraduate students. In 2015, the Ministry of Education had an approved budget of BRL 103.3 billion.

Ministry of Health and ANVISA: The Brazilian Ministry of Health performs an implicit role in the Brazilian national system of innovation, as it is an important part of the important Brazilian sectoral system of health and pharmaceutical industry. The Brazilian National Health System (SUS), which was created to emulate the UK's NHS, is the largest buyer of drugs and equipment, so its procurement decisions have the power to influence the developments of the health and pharmaceutical industry in Brazil. Furthermore, two important institutions in the Brazilian innovation system are affiliated to the Ministry. One is ANVISA, which is Brazil's equivalent of the US FDA and plays an important role in the review of priority pharmaceutical and biotechnology patents. The other is Fiocruz. In 2015, the Ministry of Health had an approved budget of BRL 121.0 billion.

Ministry of Defense: Similar to the roles performed by the Ministries of Education and of Health, policies executed by the Ministry of Defense (MoD) draw on and have a direct impact on the Brazilian system of innovation. The MoD, created in 1999, is the civilian authority that oversees the Brazilian armed forces (Army, Navy, and Aeronautics), which were previously represented by their own ministries. The Ministry of Defense is responsible for policy-making in the area of national security, which is governed by specific laws that cover areas such as the strategic procurement of technologies. Whilst MD has one of the largest budgets amongst all 23 ministries of the Brazilian federal government (usually amongst the top five), just a fraction of it is used in investments (the majority goes to wages, operating, maintenance costs, and debt) (Brustolin, 2014).

Mining and Energy Ministry (MME) and the Energy Research Enterprise (EPE): The Mining and Energy Ministry is responsible for the policy-making and structural programs in the areas of geology, mineral, and energy resources; the use of hydraulic energy; mining and metallurgy; and oil, fuels and electricity, including nuclear. It is composed of four secretaries: Oil, Gas and Biofuels; Geology and Mining; Electricity; and Energy Planning and Development. It is

through the Energy Planning and Development secretary that MME develops long-term structuring actions for the implementation of sectoral policies, including commissioning prospective studies on technologies. The Energy Research Enterprise was created in 2004 to carry out studies and research projects to support Brazil's energy policy and long-term planning.

Ministry of Agriculture, Livestock and Supply (MAPA) and the Brazilian Agricultural Research Corporation (Embrapa): MAPA is responsible for conceiving and managing public policies for stimulating agriculture, promoting the development of the agribusiness industry, and for establishing and enforcing sectoral standards and regulations. MAPA oversees Embrapa, which was founded in 1973 and is an agricultural research agency of internationally recognized excellence with research units in every region of Brazil, virtual laboratories for international cooperation, and offices in Latin America and Africa. Through Embrapa's research, Brazil managed to transform soil from the *Cerrado* (one of the country's biomes) into fertile land for agriculture – an effort known as the 'conquering of the Cerrado' – and nowadays responsible for half of Brazil's grain production. Embrapa's research resulted in a considerable increase in productivity of livestock (meat) production. Its research is divided into eight themes: low-carbon agriculture; coping with droughts;, biological nitrogen fixation; integrated crop livestock forestry systems; Matopiba (a subregion in Cerrado, considered Brazil's agricultural frontier); mechanization and precision agriculture; fishery and aquaculture; food security, nutrition and health; and Agri-ecological zoning. Embrapa is a leading example of mission-oriented research institution from Brazil.

Environmental Ministry (MMA): MMA was created in 1992, which was not coincidently the year when Rio de Janeiro hosted the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. MMA's mission is to promote policies for the protection and sustainable research and use of the natural environment. MMA has a strategic role in formulating and implementing transversal policies that aligns governmental initiatives across ministries with sustainable principles and practices.

AI.4.2. Regulatory agencies

The privatization of firms and the opening of economic sectors to competition signaled a major change in the Brazilian economy the 1990s and the associated role of the state, which moved away from production and took on more supervisory roles. The process led to the establishment of regulatory agencies that would oversee the operation of firms and sectors that had

previously been under state control (such as natural monopolies). The first generation of agencies, established between 1996 and 1998, was directly connected to the privatization process: ANP (the oil and gas regulatory agencies), Anatel (telecommunications sector), and Aneel (electricity sector). Their roles were to ensure fair and reasonable prices and tariffs, access to monopolized infrastructure, quality of services, and security of supply. They were also responsible for overseeing mandated R&D programs, which, in some sectors, were a counterpart of the privatization process.

Aneel, for instance, coordinates a large sectoral R&D program, which was established in 2000 through Law 9,991. This is the main source of funds R&D and innovation investments in the sector, with resources coming from a levy on the consumption of electricity. The Program requires that firms in all segments of the electricity production, transmission, and distribution chain invest a minimum annual amount in R&D and innovation. Those investments are partly covered by public funds collected through the levy on consumption. This is an interesting program to promote R&D and innovation investments in a sector whose natural monopoly characteristics provide little incentive to do so. Until recently, however, public resources were not directed to specific technologies (investments are decided by the companies). Yet, resources from Aneel were also used for *Inova Energia*, complementing the funding provided by Finep and BNDES.

A second generation of agencies created in 1999–2001 was not connected to the privatization process: Anvisa (health sector), ANA (water sector), ANS (which oversees private health insurers), Antaq (waterways sector), ANTT (roads land transport sector), and Ancine (film sector). Besides overseeing their respective sectors, these agencies were also responsible for policy-making and policy-execution, including provision of funding, as in the case of Ancine. A third generation can be identified with the creation of Anac in 2005, the civil aviation agency.

AI.4.3. Intellectual property

Brazilian patent and trademark office INPI: The Brazilian intellectual property office is responsible for examining and granting patents, trademarks, and industrial design registrations (utility models), among other types of intellectual properties. It is also responsible for auditing technology transfer contracts and for establishing the Brazilian system of protected designation of origin (including the recognition of foreign designations). A key issue facing INPI is its huge backlog of applications: the average waiting time for an examination after an application is filed is 10 years. This has been (at least partly) due to a change in

the Brazilian IP legislation in the mid-1990s, which started to recognize patent rights in pharma, agriculture, and biotech. However, critics have pointed to inefficiencies in the INPI patent and trademark granting process.

Núcleos de Inovação Tecnológica (NIT) (Technological Innovation Centers): The Innovation Law of 2004 established that science and technology research institutions, including universities, should establish Technological Innovation Centers that would be responsible for managing the institution's innovation policies and intellectual properties, particularly their licensing and technology transfer agreements. This resulted in a diagnosis that Brazilian research institutions were good at basic research, but that this research was not being applied to practical solutions or resulting in commercial innovations. The NITs were proposed as means to tackle the issue and promote licensing and transfer of research and inventions developed by these institutions. A criticism of the proposal is that the linear model of innovation still underlies it. Furthermore, even the most well-structured NITs, from the University of São Paulo (USP) and University of Campinas (Unicamp), present disappointing results in terms of revenues from licensing, but incur high maintenance costs of patents (Cassiolato *et al*., 2015).

AI.4.4. Quasi-governmental organizations ('social organizations')[25]

Brazilian Agency of Industrial Development (ABDI): ABDI is an autonomous social service institution, founded in 2004 as a link between the MDIC and the business sector, with the mission of developing strategic actions connected to the Brazilian industrial policy, promoting productive investment, employment, innovation, and industrial competitiveness of the country. It currently plays a key role of continuously monitoring the implementation of the latest industrial policy plan (Plano Brasil Maior) and the achievement of its goals.

Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE): Created at the end of 2011 and associated with the Ministry of Science, Technology and Innovation, CGEE is a social organization that advises STI policies and initiatives, through foresight and prospective studies. It thus contributes to the formulation and revision of industrial policies through studies and publications. Its activities are divided into four lines of action: (1)

[25] In Brazil, the character of a 'social organization' is granted by the government to a private, non-profit that fulfils certain conditions, so it can receive benefits from the government, such as budget allocations, tax exemptions, etc., for performing its aims, which must necessarily be in the community interest. Whilst the social organization has decision-making autonomy and is regulated by laws for private institutions, the state strategically encourages and controls its activities through a contract. An 'autonomous social service' institution performs a similar role as a social organization, but is governed by similar legislation as public agencies.

promote studies, analysis, and evaluation that subsidizes science, technology, and innovation policies; (2) articulate the different public and private actors of the Brazilian system of innovation (a 'brokerage' role); (3) support the management of the Brazilian NSI by MCTI and its agencies; and (4) dissemination of information and data on the Brazilian NSI.

Brazilian Enterprise for Industrial Research and Innovation (Embrapii): Embrapii was founded in 2013 a social organization by MCTI and the Ministry of Education (MEC) – which co-funds the institution – as an Embrapa for the industrial sector. It links research institutions and universities with the industrial sector. Its mission is to contribute to the innovative effort of Brazilian industry by strengthening its collaboration with research institutes and universities. To this end, it supports technological research institutions in specific areas of competence, which are selected to execute technology research development projects for innovation in cooperation with industrial companies, whose technological needs and productive bottlenecks are identified in advance by Embrapii. Although it is funded from the federal budget, Embrapii is an autonomous organization that independently decides the allocation of its resources. The costs of projects are equally shared by Embrapii, the enterprise, and the research institute.

ANNEX II: Semi-structured interview template

AII.1. Briefing

The Brazilian Ministry of Science, Technology and Innovation (MCTI) has commissioned a study about the Brazilian system of science, technology and innovation, which will deliver an inspirational think-piece based on the ground-breaking work on the entrepreneurial state developed by Professor Mariana Mazzucato (Science Policy Research Unit – SPRU, University of Sussex).

The study has the following goals: (a) To provide an overview of the current arrangement of the Brazilian system of innovation, based on existing analyses and interviews with key public and private agents of the system; and (b) To develop a proposal for the transformation of the Brazilian system of innovation into a mission-oriented system of innovation (the classic examples of mission-oriented policies were the Manhattan and Apollo projects, which produced the atom bomb and put a man on the moon, respectively).

AII.2. Interview template

A) The Brazilian system of innovation: strengths and weaknesses
   i. *What are the strengths of the Brazilian system of science, technology, and innovation?*
   ii. *What are the weaknesses of the Brazilian system of STI?*
   iii. *How has the Brazilian system of STI evolved in the past decade?*
      - *Prompt: Has it improved, worsened, or stagnated?*
   iv. *Do you agree with the following statement: "The Brazilian system of science, technology, and innovation is good at advancing the knowledge frontier through basic research, but is unable to transform new knowledge into innovations"?*
      - *Prompt: Why do you (dis)agree?*
   v. *In your opinion, what is missing in the Brazilian system of STI in order for it to thrive and become more innovative?*

B) Public–private interactions and networks in the Brazilian system of science, technology, and innovation
   i. *What are and should be the roles of public and private agents (institutions, organizations) in the Brazilian system of STI?*
   ii. *How would you characterize the interactions between public and private agents in the Brazilian system of STI?*

- *Prompt: Describe your experience in interacting with (other) public and private agents (institutions, organizations)?*

iii. *In your opinion, which of the following describes the interactions between public and private agents (institutions, organizations) in the Brazilian Innovation system, and why?:*

- *Symbiotic: Public and private agents benefit from the actions of one another, sharing risks and rewards of the research, development, and innovation process.*
- *Parasitic: Some agents in the system benefit more than others, and risks and rewards are unevenly distributed.*
  - *Prompt: What type(s) of agents benefit more than others?*
- *Antagonistic: public and private agents are incapable of cooperating.*

C) Direct vs. indirect STI policies, importance of different instruments

i. *In your opinion, what are the key issues that public policies must address in order to make the Brazilian system of STI more effective/dynamic?*

ii. *What can be done to make the Brazilian system of STI more effective/dynamic?*

iii. *What are the key barriers in the Brazilian innovation system that prevent businesses from engaging in innovation projects?*

- *Prompt: mention the lack of public financial incentives, an adequate legal framework, legal guarantees for the first mover (innovator), expertise (PhDs, scientists), private partners (SMEs), technological/industrial clusters, and weak institutional environment (including corruption).*

iv. *Which type of public policies and instruments would be most effective at incentivizing businesses to invest in R&D and STI projects? (Open-ended question)*

v. *Which of the following types of public financial instruments/incentives are most effective at leveraging private investments in R&D and STI projects – please put in order (listed here in alphabetical order):*

- *Debt (fixed income), such as BNDES financing with subsidized interest rates;*
- *Equity (variable income), such as the investments by BNDESPar in innovative start-ups;*
- *Grants and subsidies, such as the FNDCT and the sectoral funds, and FINEP's programs;*

- *Public procurement for innovation, such as Ministry of Defense programs;*
- *R&D tax credits, such as those set forth by Lei do Bem*
- *Other (which ones? What financial instruments need to be created in Brazil?)*

vi. *What non-financial policies are effective in Brazil and what are lacking?*
- *Prompt: mention public networking and brokerage, systemic policies, investments in education and training, regulation, support for private demand, public procurement for innovation, public–private partnerships.*

vii. *In your opinion, which option best describes the level of direct <u>public</u> investments in R&D and STI projects (including innovative start-ups), and why?:*
- *Too low*
- *Too high*
- *Sufficient*

viii. *In your opinion, which option best describes the level of <u>private</u> investments in R&D and STI projects, and why?:*
- *Too low*
- *Too high*
- *Sufficient*

ix. *In your opinion, which of these options best describes what direct public investments in R&D and STI do, and why?:*
- *<u>Crowd out</u> private investments*
- *<u>Crowd in</u> private investments*
- *Makes the Brazilian economy <u>more dynamic</u> (creates new technological opportunities)*
- *Makes the Brazilian economy <u>more lethargic</u> (shuts down technological opportunities)*

D) <u>Risks and rewards: sharing successes and failures; the issue of inequality and other societal challenges</u>

i. *Consider a situation in which the public sector makes the key investments in basic and applied R&D and in bringing the resulting innovation to market, but the final product is commercialized by a private enterprise.*
- *What do you think about this situation?*
- *How should the risks and rewards from such investments in innovation be shared between public and private agents?*

ii. *The innovation process is extremely risky and fundamentally uncertain – most projects fail, and those that succeed take years if not decades to mature. Therefore, public or private investments in R&D and innovation will often fail, and only some successful projects will result in high profits. In your opinion, is it:*
    - *Acceptable for the public sector to invest in projects that fail, because it is the only way to achieve success?*
    - *Not acceptable for the public sector to invest in projects that fail, because it is using taxpayers' money.*

iii. *Despite criticism, public institutions like BNDES and FINEP will continue to directly invest in R&D and innovation processes. Considering that some of the investments will fail and others will succeed, how do you think these (and other public) institutions should structure their portfolio of investments?*
    - *How would such portfolios differ (or not) from a private venture capital portfolio or the portfolio of R&D investments by private enterprises?*

iv. *In industrialized countries, the drive for innovation policies has been shifted from competitiveness to what have been labeled 'great societal challenges'; for instance, climate change, ageing, obesity, energy and resource security, traffic and transport, sustainability, etc. This is visible in research and innovation policy frameworks such as EU's Horizon 2020 framework (and also OECD's innovation strategy plan). In your opinion, what are the key challenges that can be drivers for STI policies and private investments in R&D and STI projects in Brazil?*

v. *Do you believe that STI policies and policies that seek to address socio-economic inequality (between individuals and regions) should be treated together or separately?*

E) Suggestions and follow-up

i. *What types of study (understanding) are missing from the debate on the Brazilian system of STI?*

ii. *What would you like to learn from a study like this one?*

iii. *Do you have any further suggestions or questions?*

iv. *Would you be happy to answer follow-up questions by email?*

ANNEX III: List of interviewed institutions

The study interviewed representatives from the following governmental agencies:

- MCTI (two interviews with five senior/first-tier representatives)
- MDIC (two interviews with two senior/first-tier representatives)
- CGEE (one interview with the president)
- TCU (one interview with director of the *Serzedello Corrêa Institute*)

The study interviewed representatives from the following public funding agencies:

- FINEP (two interviews with one senior/first-tier superintendent and two managers concerned with *Inova* programs)
- BNDES (four interviews with two directors, one head of department, and two managers concerned with *Inova* programs)
- CNPq (one interview with two senior coordinators of technology, innovation and competitiveness programs)

The study interviewed representatives from the following research and academic organizations:

- Embrapa (two interviews with the president and one senior civil servant)
- Fiocruz (one interview with the president)
- AEB (one interview with the president)

The study interviewed representatives from the following quasi-governmental organizations:

- ABDI (one interview with one director, one project manager and one coordinator of the aerospace and defense sector)
- Embrapii (one interview with the director of planning and management and two representatives of IEL/CNI)

The study also sought to interview representatives from business enterprises, but the response rate to the contacts made was rather low. We were able to interview senior representatives of four companies – two of national capital: CPFL, from the electricity sector (one interview with the director of R&D and innovation and one senior manager); and Embraer, from the aerospace sector (one interview with the chief operating officer); and two of foreign capital, IBM, from the ICT sector (one interview with the Latin America general manager);

and EDP, from the electricity sector (one interview with the director of strategy). We also interviewed one senior private fund manager (from Inseed), and the president of the industry association, CNI. Inputs from senior business representatives were used to triangulate the evidence gathered from the public sector institutions.

O Centro de Gestão e Estudos Estratégicos (CGEE) tem como missão institucional subsidiar os processos de tomada de decisão em temas relacionados à ciência, tecnologia e inovação, por meio de estudos em prospecção e avaliação estratégica baseados em ampla articulação com especialistas e instituições do SNCTI.

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